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VOL. XLV] JUNE 7, 1965 [No. 1

Coefficients of Correlation and Distance in Numerical Taxonomy [1, 2]

BY

F. JAMES ROHLF [3] and ROBERT R. SOKAL [4]

Department of Entomology
The University of Kansas, Lawrence

ABSTRACT: This is an investigation of the properties of two coefficients of similarity in numerical taxonomy: correlation (Michener and Sokal, 1957) and distance (Sokal, 1961). The study is based upon analyses of 97 species of bees by Michener and Sokal (1957) and 48 species of mosquitoes by Rohlf (1962). Characters in these studies generally possessed several linearly ordered states. The effect of standardization of characters (*i. e.*, transformation of the character state codes to achieve a mean of zero and a variance of unity) is slight upon the distance coefficient. Correlation coefficients are affected to a greater degree and there is a definite nonlinear relationship between correlation coefficients based on standardized and on unstandardized characters. Comparisons between coefficients of correlation and distance based upon standardized characters do not as yet permit conclusions on the relative merits of the two, except in special cases. Biological and mathematical interpretations of these coefficients are discussed. The theoretical frequency distributions of these coefficients are given and compared with the observed distributions. The properties of several alternative distance coefficients are briefly examined. A summary of recommendations for carrying out numerical taxonomic studies is given, based on the present state of our knowledge.

1. Contribution number 1175 from the Department of Entomology, University of Kansas, and paper No. 4 in a series entitled *Experiments in Numerical Taxonomy*, of which Sokal (1961), Rohlf and Sokal (1962), and Sokal and Rohlf (1962) are the first three papers, respectively.

2. This investigation was supported in part by a research grant from the National Institute of Allergy and Infections Diseases, U. S. Public Health Service.

3. Present address: Department of Biological Sciences, University of California, Santa Barbara. Parts of this investigation were carried out during the tenure of a predoctoral fellowship from the Division of General Medical Sciences, United States Public Health Service, by Rohlf.

4. We are indebted to Mrs. Julie C. Sokal, Richard C. Rinkel and Paul A. Thomas for computational assistance. Mrs. Maxine L. Howe helped with the clerical work and Mrs. Julie C. Sokal prepared the illustrations.

I. INTRODUCTION

The present paper investigates the effect of standardization of characters on correlation and distance coefficients in numerical taxonomy. These studies are carried out using the data on 97 species of bees by Michener and Sokal (1957) and 48 species of mosquitoes analyzed by Rohlf (1962).

As numerical taxonomy develops and its application spreads it is important to examine theoretically and empirically the validity of its assumptions and techniques. Three types of similarity coefficients have been proposed in numerical taxonomy: association coefficients, correlation coefficients, and distance coefficients. The latter two have been most frequently used with higher organisms owing to the nature of the characters employed in taxonomic work on these groups. No critical comparison has so far been made between these two types of coefficients. The present paper, while not definitive, will provide the first comparative study of these coefficients.

As early as 1957 Michener and Sokal recognized that in order to overcome the distortions in correlation coefficients due to different numbers of states per character it was desirable to standardize the characters to give them a common mean and unit variance. However, the limitations of their computational equipment at the time did not permit them to carry out such computations. The effects of standardization on Michener and Sokal's data are described here and compared with the earlier results. In his study of the mosquito genus *Aedes,* Rohlf (1962) employed both standardized and unstandardized character state codes. The comparisons are presented below.

Since the principles and procedures of numerical taxonomy have been adequately detailed elsewhere (Sokal, 1960; Sneath and Sokal, 1962; Sokal and Sneath, 1963) no further discussion of these is made here. Interested readers are referred to these papers.

II. MATERIALS

The original bee data from Michener and Sokal (1957) were repunched on a new set of IBM cards in order to permit processing by newly-developed techniques for the IBM 650 computer. The general correlational and clustering procedures were as described by Sokal and Michener (1958). Detailed modifications will be described below as needed. The programs for processing these data were largely developed by one of us (FJR). The 48 species

of the genus *Aedes* were employed in a numerical taxonomic study by Rohlf (1962). They belong to eight subgenera. Both larval and adult characters were studied and the correlations and distances were computed between species based on larval, adult and both sets of characters. The computations presented here were by-products of an investigation examining the congruence of larval and adult classifications (Rohlf, 1963). In the bee study 122 characters were employed, while the mosquito study was based upon 148 characters. Lists of the species and characters studied and biological information on them are furnished in the original sources already referred to.

III. STANDARDIZATION OF CHARACTERS

Standardization seems desirable since the coding of the various character states is arbitrary and consequently the number of states and the units of measurement vary from character to character. In order to pool the information from different characters, it is desirable to transform all characters in a given study to a comparable scale.

Early steps in this direction were taken by Smirnov (1925) and by Haltenorth (1937). The former standardized deviations of taxa from the means of their groups (by division by the mean), while the latter expressed all measures (of the skulls of cats) as percentages of the basal lengths of these skulls.

Cain and Harrison (1958) dealt with the problem of standardization by using the maximum expression of a character as 100 percent and arbitrarily grading all other expressions of the character as some portion of this total percentage. They called the transformed character state codes "reduced values." Since they used zero when a character was absent (or minimal), the effect of their transformation was to give all of the characters an equal range. There are two difficulties with this procedure. First, the admission of an OTU (operational taxonomic unit—the lowest taxonomic unit being classified—see Sokal and Sneath, 1963, for a more detailed discussion) with a character state scored beyond the previous 100 percent level would necessitate the recalculation of all of the "reduced" state codes for the character; hence, the degree of similarity between the OTU's previously studied would be affected. The second is that the reduced character state codes are not readily amenable to rigorous statistical methods.

A procedure proposed for use in numerical taxonomy by Sokal (1961) is standardization of the characters (*i. e.*, rows of the data matrix). To do so we transform each character to obtain a mean

of zero and a variance of unity. This is easily done by the following transformation:

$$X'_{ij} = \frac{X_{ij} - \bar{X}_i}{s_i}$$

where X_{ij} is the character state value for OTU j on character i, $\bar{X}_i$ is the mean of character i, s_i is the standard deviation of character i, and X'_{ij} is the standardized character state code.

The inclusion of additional OTU's to a numerical taxonomic study with standardized characters will not have much effect on the means and standard deviations of the characters unless the new character states are very extreme and/or the previous study was based on very few OTU's. Hence, it usually will not be necessary to re-standardize the characters every time a new OTU is added to the study. Another desirable feature is that the relationships among the previously studied OTU's will be affected little by the addition of other OTU's. The procedure to use when a new OTU is added, is to express its character state codes in terms of character means and standard deviations based on the previously studied OTU's.

IV. SIMILARITY COEFFICIENTS

The selection of the appropriate coefficient depends upon the assumptions made about the characters used in the study and the manner in which they were recorded (Rohlf, 1962; Sokal and Sneath, 1963). If the states of each character used could not be linearly ordered a coefficient of association would be the most appropriate (however, in two-state characters, whether linearly ordered or not, all three types of coefficients can be used). A common coefficient of association is the simple matching coefficient which is the number of characters for which two OTU's match divided by the number of characters considered (Zubin, 1938; Cattell, 1949; and Sokal and Michener, 1958). This type of coefficient has been often used in psychology and ecology. Sneath (1957) and Rogers and Tanimoto (1960) show taxonomic applications of various association coefficients. In the present study only correlation and distance coefficients are considered.

a. Correlation Coefficients

The only correlation coefficient that has so far been employed in numerical taxonomy is the Pearson product-moment correlation coefficient. It was introduced to numerical taxonomy by Michener and Sokal (1957) and Sokal and Michener (1958). Its formula is too well-known to need repetition here.

Correlation coefficients can be interpreted in several ways. Their common interpretation is as a measure of covariation. If two variables vary in such a way that as one increases in value the other one does likewise and conversely, as the first one decreases the second one follows, then these variables covary and are said to be positively correlated. In numerical taxonomy this means that two OTU's are positively and highly correlated if changes in character state score from character to character in one OTU are paralleled in the other.

A useful interpretation can be made through geometry when standardized characters are used. Figure 1 will explain this in a

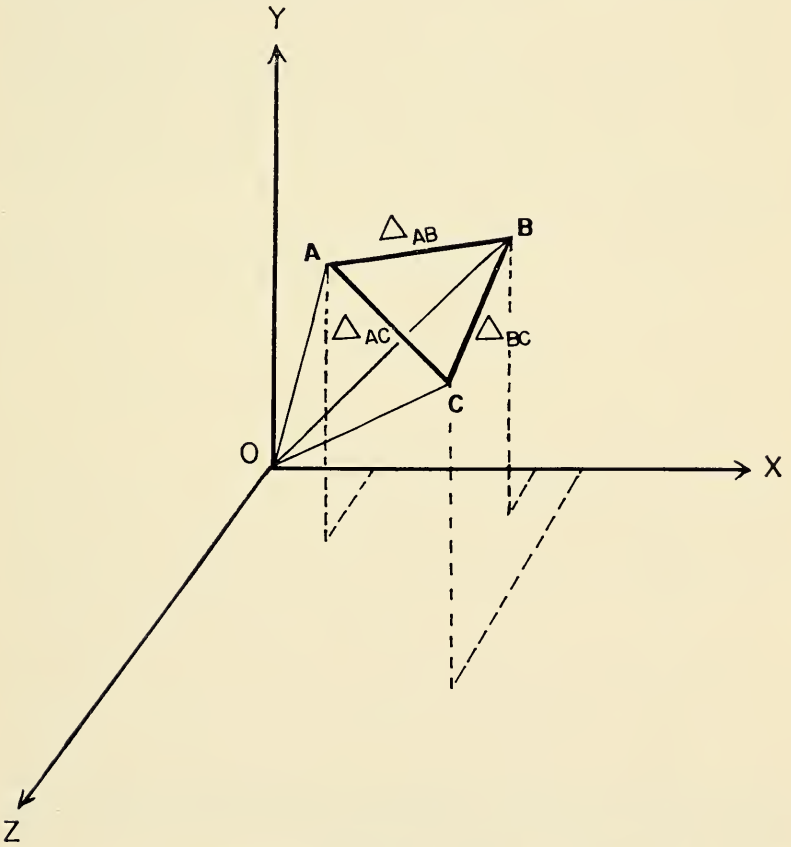

FIG. 1.—Two dimensional representation of three OTU's plotted in a three dimensional space. The OTU's A, B, and C are plotted with respect to three character axes *X*, *Y*, *Z* defining a three dimensional space. Distances between OTU's are identified by △. Correlations between OTU's are functions of the angle between the lines connecting them to the origin, O. For further explanation see text.

simplified model based on only three characters. These characters are called *X*, *Y* and *Z* and represented by the three co-ordinate axes of the figure. Each OTU (three are shown in the present diagram but, of course, any number could be used) is plotted in the three-dimensional figure according to the scores of its character state codes for the three characters. Each OTU therefore assumes a fixed position in the three-dimensional space. The angle between the lines connecting any two OTU's to the origin is a measure of the similarity between them, since in general the closer the OTU's are to each other in the three dimensional space the smaller this angle will be. The correlation coefficient can be interpreted as the cosine of this angle (which will be 1 for an angle of 0°, 0 for an angle of 90° and –1 for an angle of 180°). This model is not strictly true since the columns of the data matrix (the OTU's) do not have means exactly equal to zero but when standardized characters are used the model is accurate enough to permit one to visualize the relationships. In the present study it was found that the observed means of the OTU's, after the characters had been standardized, were very close to zero.

The importance of standardization when correlation coefficients are used can be seen from the fictitious example in Table 1. OTU's

TABLE 1.—Hypothetical Data to Demonstrate Effect of Sandardization of Characters.

CHARACTERS	Possible state codes	OTU's	
		1	2
1	1, 2	1	2
2	1, 2, 3	3	1
3	1, 2, 3, 4	1	4
4	1, 2, 3, 4, 5	5	1
5	1, 2, 3, 4, 5, 6	1	6

1 and 2 exhibit maximum differences for the given range of character state codes, yet the correlation between OTU's 1 and 2 is only –0.696, and not –1.000 as one might expect.

When the characters are transformed, by equalizing their range or by standardization or even by simply giving all of them the same mean, the correlation between the two OTU's is –1.00. It would seem that with unstandardized data, it is impossible to get very

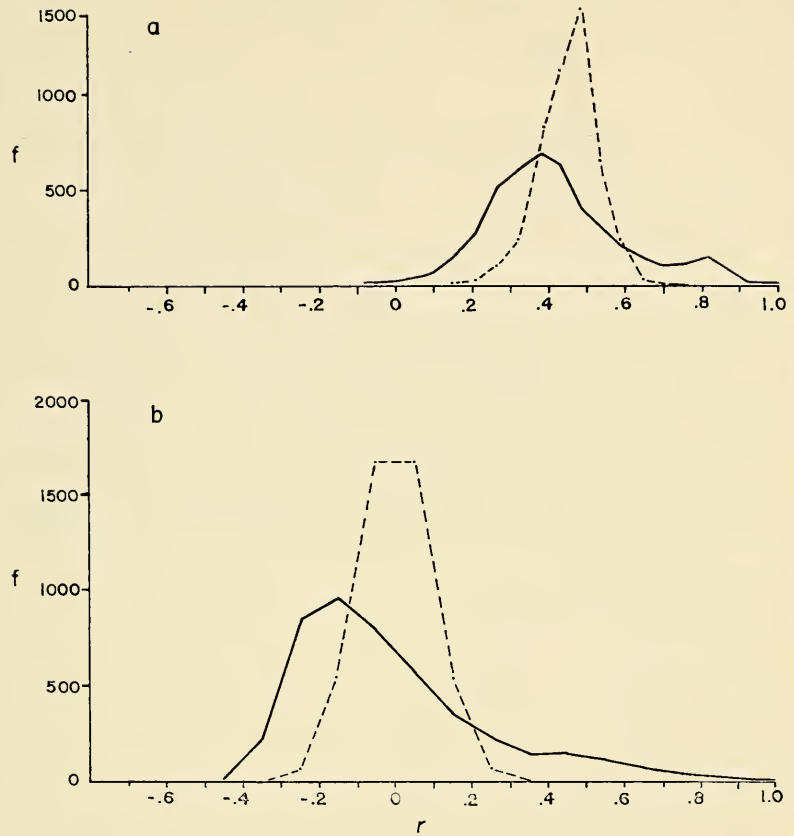

FIG. 2.—Observed and expected frequency distributions of correlation coefficients from the bee study of Michener and Sokal (1957). *a*. Upper graph shows correlation coefficients based on characters that had not been standardized. *b*. Lower graph shows correlations based upon standardized characters. Abscissas give magnitude of correlation coefficient, *r*, while ordinates indicate frequencies of correlation coefficients. Solid lines show observed frequencies, dashed lines show expected frequencies on the basis of the observed mean in graph *a* and of a mean of zero in graph *b*.

high negative correlations; it is, therefore, probably unlikely that in any actual study many negative correlations would be found at all.

The above appears to explain why Michener and Sokal (1957) found virtually no negative correlations in their study, based upon unstandardized data (Figure 2a), while Rohlf (1962) found no negative correlations among his coefficients based on unstandardized data (Figure 3a). When the correlations were recomputed based on stardardized characters, the average correlation among the bees decreased from 0.418 to –0.009 (see Figure 2b), while

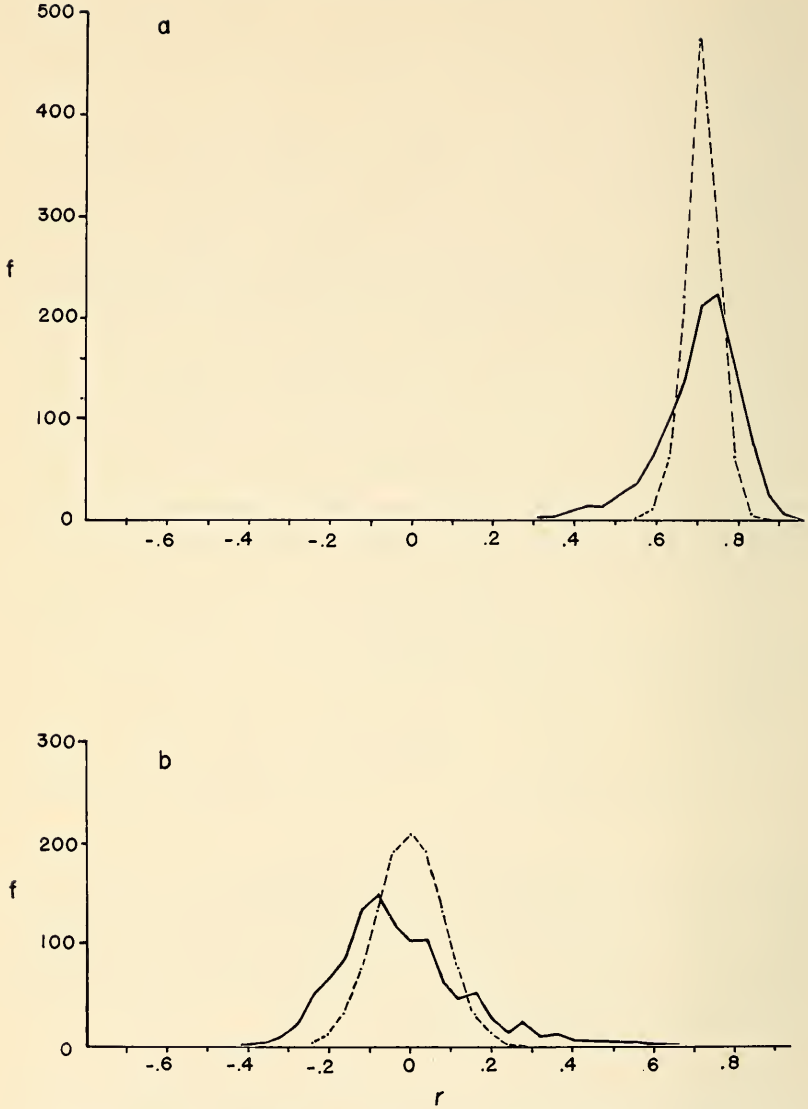

FIG. 3.—Observed and expected frequency distribution of correlation coefficients from the mosquito study of Rohlf (1962). Explanation as in Figure 2.

in the *Aedes* data a corresponding shift in the average correlation from 0.703 to –0.018 took place (Fig. 3b).

Standardization of the character state codes raised the standard deviations slightly in both studies, from 0.185 to 0.253 and from 0.100 to 0.157 in bees and mosquitoes, respectively. From an inspection of the frequency distributions in Figs. 2 and 3 it can be

seen that the standardization of the characters affects both the position of the frequency distribution along the abscissa and also the shape of the distributions.

It will be noted that the average correlation for each matrix of coefficients based on standardized characters approached zero very closely and cannot in fact be shown to be significantly different from zero. We believe the expected value of this average (based on stardardized characters) to be zero, although we have not demonstrated this mathematically.

It is of interest to study the observed frequency distributions of the product-moment correlation coefficients in relation to their theoretical distributions. These were calculated using an expected value of zero for the correlations based on standardized characters and on an expected value equal to the observed mean correlation for the correlations based on unstandardized characters. The expected distribution of the correlation coefficient has been tabled by David (1938), but Rohlf (1962) found it more convenient to approximate the distribution using z's than to interpolate in her tables, since a simple linear interpolation was found not to be sufficiently accurate. For n greater than 25 (true of all our cases), the z transformation gives results very close to the actual distribution (David, 1938).

Figures 4 and 5 show two-way frequency distributions of the correlations based on unstandardized and standardized characters for each pair of species. The frequencies in each cell of the two-way frequency distribution are represented by black circles. The size of each circle indicates the magnitude of the frequencies it represents according to a key shown in the upper left corner of each figure. The general shapes of these two frequency distributions are quite similar. The relationship is clearly nonlinear and appears constrained by the upper limit of the correlation based on unstandardized characters. When correlation coefficients between the two types of r's are calculated for the data on which these figures are based we find these to be 0.89 and 0.63 for the bees and mosquitoes, respectively.

b. Distance Coefficients

A distance coefficient expresses the dissimilarity between two OTU's as a geometric distance between the two points (corresponding to the two OTU's) in an n-dimensional Euclidian space defined by the n characters as co-ordinate axes. Sokal (1961) discusses the geometric interpretation of a distance coefficient and its relation to other similar indices. A distance coefficient can be easily calculated

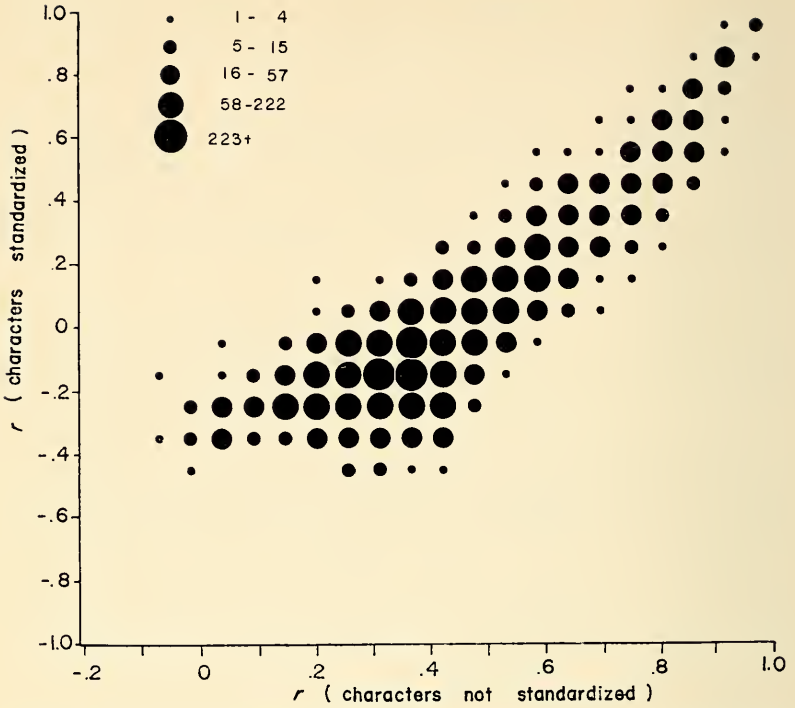

FIG. 4.—Two-way frequency distribution of the correlation coefficients based on unstandardized and standardized characters for each pair of species in the bee study by Michener and Sokal (1957). The abscissa and ordinate indicate the magnitude of the correlation coefficient. The frequencies in each cell of the two-way frequency distribution are represented by solid circles. The size of each circle indicates the magnitude of the frequency according to the key shown in the upper left corner of the graph. The graph is based on 4,656 correlation coefficients. The correlation coefficient between the two variables is 0.89.

(assuming orthogonal co-ordinate axes) by an extension of the Pythagorean Theorem to an n-dimensional space. The taxonomic distance, between OTU's j and k, $\triangle_{jk}$, is defined as

$$\triangle_{jk} = \left[\sum_{i=1}^{n} (X_{ij} - X_{ik})^2 \right]^{1/2}$$

where X_{ij} is the state code of OTU j for character i and n is the number of characters in the study. The quantity $\triangle_{jk}^2$ was called δ_{jk}^2 by Sokal (1961). We are changing symbolism here (in agreement with Sokal and Sneath, 1963) in order to conform to the conventional statistical usage of employing lower case Greek letters for parameters. Since we are reserving the lower case English d for average distance as specified below and since D is used for Ma-

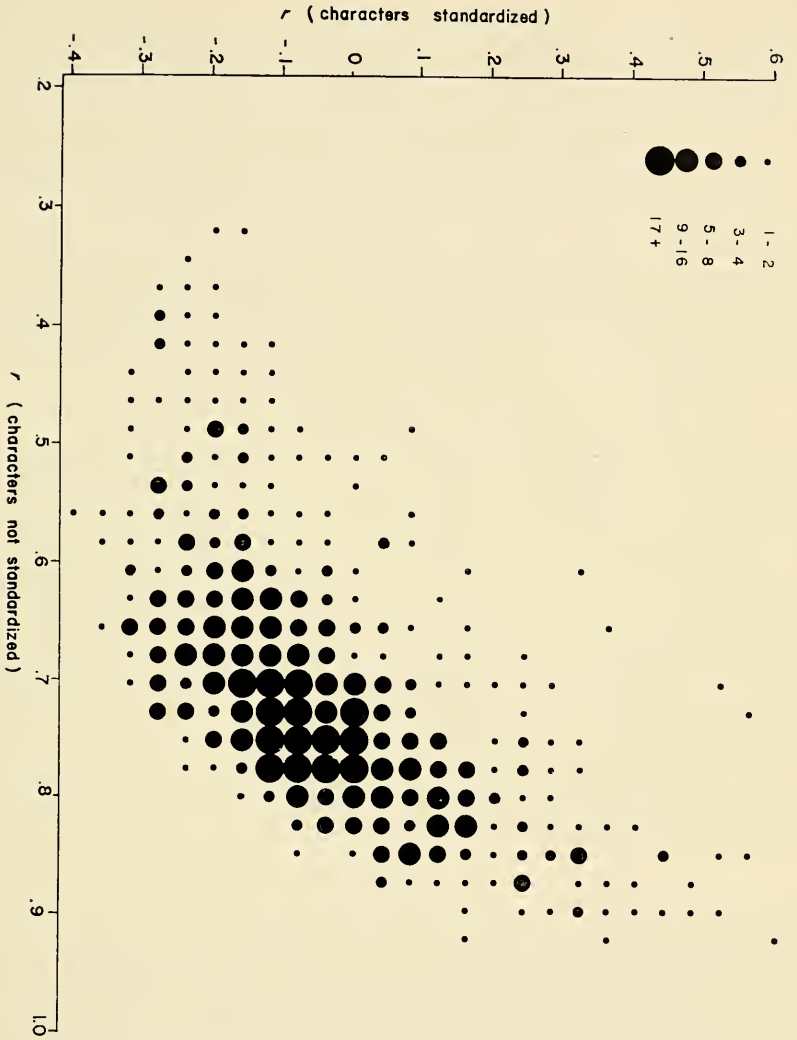

FIG. 5.—Two-way frequency distribution of the correlation coefficients based on unstandardized and standardized characters for each pair of species in the mosquito study by Rohlf (1962). Arrangement of graph as in Figure 4. Since the total number of correlations in this study was 1,128, each circle represents fewer frequencies as shown in the key at the upper left corner of the graph. The correlation coefficient between the two variables is 0.63.

halanobis' generalized distance we settled on Δ for the above quantity. As Δ_{jk} tends to increase with an increase of n, an average distance makes it possible to compare distances based on different numbers of characters. Such an average was employed by Sokal (1961) for squared distances, called $\overline{\delta_{jk}^2}$. It would be defined as

$\triangle_{jk}^2/n$ in the symbolism of this paper. Since we now prefer to use linear distances (*i. e.*, not squared ones) we shall define the average distance as $d_{jk} = \triangle_{jk}/\sqrt{n}$. This distance can also be interpreted as the standard deviation (without the Gaussian correction) of the difference between two OTU's. Sokal's $\overline{\delta_{jk}^2}$ would then be referred to as d_{jk}^2. Finally, δ_{jk} is now defined as the parametric value of d_{jk}.

In Figure 1 the distances between any two of the three OTU's can easily be seen. The distances are labelled $\triangle_{AB}$, $\triangle_{AC}$ and $\triangle_{BC}$, respectively. From the figure it is evident that the distance between pairs of OTU's is a function of both the angle between the lines connecting them to the origin and of the lengths of the lines themselves. Thus,

$$\triangle_{AB}^2 = (AO)^2 + (BO)^2 - 2(AO)\ (BO) \cos \angle\ AOB,$$

where $\triangle_{AB}$ is the distance between OTU's *A* and *B*, AO and BO are the lengths of the lines from OTU's *A* and *B* to the origin, respectively, and $\angle\ AOB$ is the angle between the two OTU's.

If all the OTU's were equidistant from the origin, say at distance *c*, then the distance would simply be a function of the angle between any 2 OTU's, *e. g.*, $\triangle_{jk} = c\sqrt{2(1 - \cos \angle\ jOk)}$, where $\triangle_{jk}$ is the distance between any two OTU's *j* and *k* and $\angle\ jOk$ is the angle between these OTU's. If the OTU's were standardized then the distance would be a simple function of the correlation coefficient, r_{jk}, between OTU's *j* and *k*,

$$\triangle_{jk} = \sqrt{2(n-1)(1-r_{jk})}.$$

The average distance under these assumptions is

$$d_{jk} = \sqrt{\frac{2(n-1)}{n}(1-r_{jk})}.$$

This function is graphed in Figure 6 for large *n*, where $(n-1)/n \rightarrow 1$. In such a case distance would have no information not contained in the correlation coefficient. Near the upper limit for correlations (lower limit for distances) the distance scale would be expanded relative to that of *r*. It is this tail of the scale which generally is of more interest in numerical taxonomy.

Since OTU's in actual practice are not standardized and are unlikely to be equidistant from the origin, the distance coefficient does convey independent information. Lengths of the lines between the OTU's and the origin are a measure of "size" of the OTU as expressed through its characters. This is a rather vague term because some characters such as color will not express size dimensions in the conventional meaning of the word.

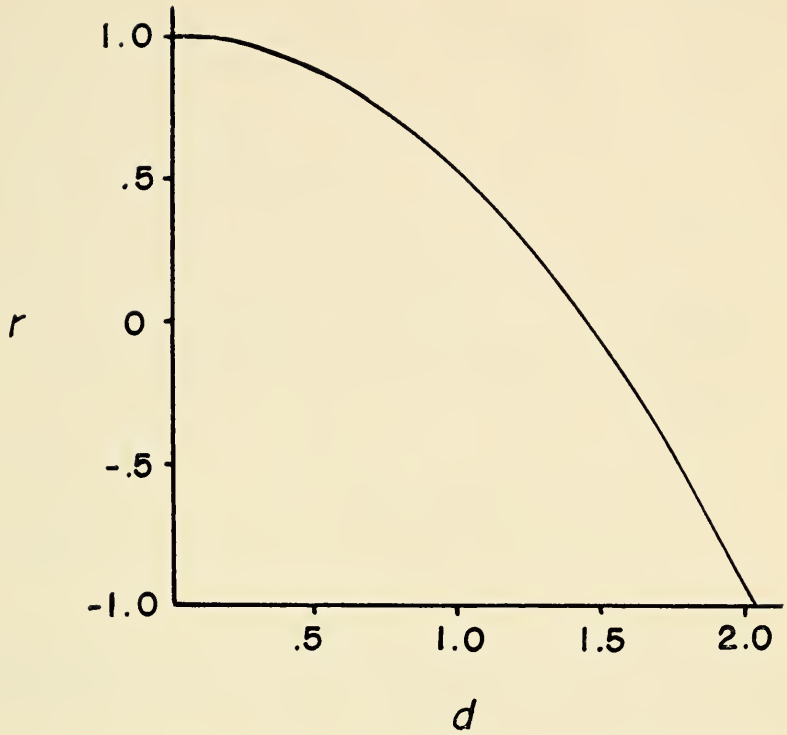

FIG. 6.—Graph of the distance coefficient, *d*, as a function of the correlation coefficient, *r*, on the assumption that the OTU's are standardized. The mathematical expression is shown in the text. The abscissa shows *d* and the ordinate *r* contrary to ordinary conventions in order to conform with the arrangement in Figures 10, 11, and 12.

It is of interest to examine the frequency distributions of the observed distance coefficients in the bee and mosquito data and to compare them with the theoretical distribution that one would expect if the distance coefficients were all drawn from the same statistical population, *i. e.*, if the true distances between all pairs of OTU's were equal and the observed distribution of distances about their mean were due to chance alone. The observed frequency distributions of distances between pairs of species in bees and mosquitoes are shown in Figure 7 and 8, respectively. Distances were computed from standardized characters in both studies and also from unstandardized characters in the mosquito study. The expected frequency distributions are superimposed on the observed frequency distributions based on standardized characters only.

In order to calculate these expected frequency distributions, it was assumed that the observations (the *n* standardized characters)

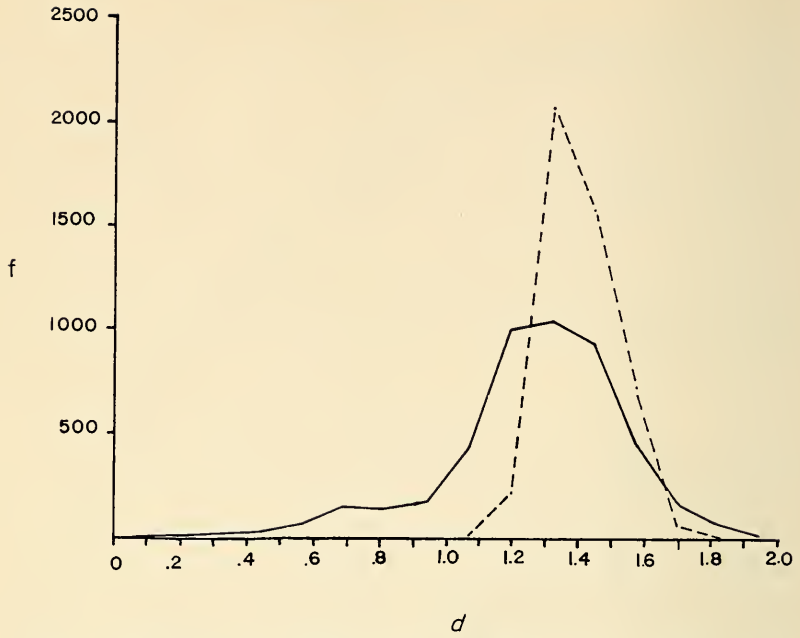

FIG. 7.—Observed and expected frequency distributions of distance coefficients based on standardized characters from the bee study of Michener and Sokal (1957). Abscissa shows distance scale, ordinate indicates frequencies. The solid line indicates observed frequencies, the dashed line gives expected frequencies based on the assumptions stated in the test.

were independent, normally distributed with a mean of zero and with unit variance. On these assumptions the variance of a difference between two variables is distributed as $2\chi^2$ (with one degree of freedom). Hence, average distances are distributed as $\sqrt{2\chi_n^2/n}$ (where χ_n^2 has the χ^2-distribution with n degrees of freedom). The easiest way to prepare the frequency distribution of such a variable is to use a transformation to another distribution which has already been adequately tabled. A suitable transformation to use would be:

$$u_{jk} = \frac{\left[\frac{d_{jk}^2}{2}\right]^{\frac{1}{3}} + \frac{2}{9n} - 1}{\sqrt{\frac{2}{9n}}}$$

This is based upon an equation for calculating the distribution of χ^2 for large degrees of freedom (n). The transformed variable u is then expected to be normally distributed with a mean of zero and

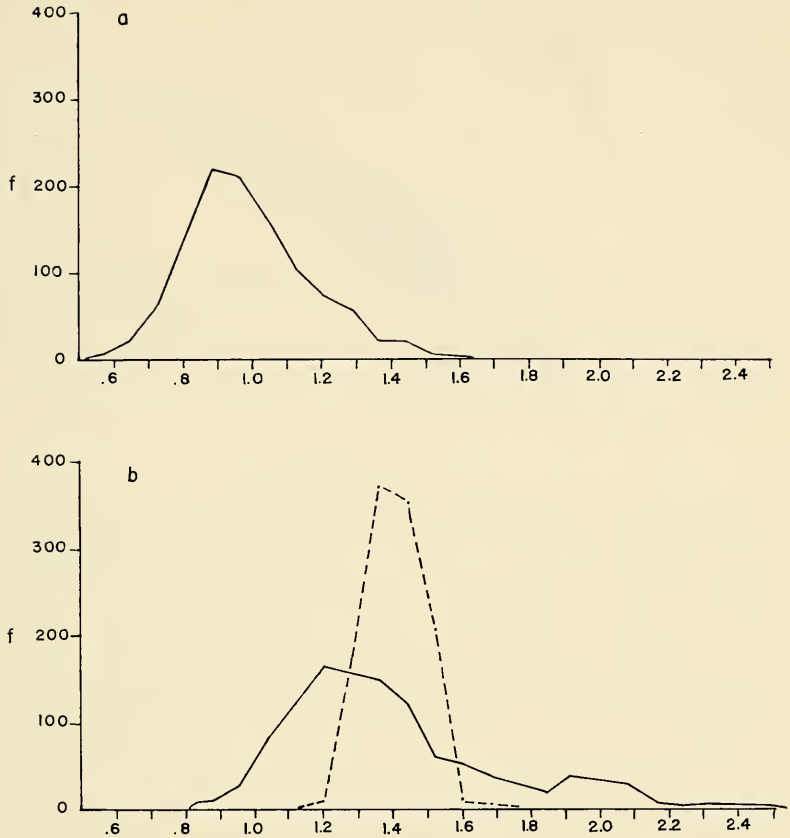

FIG. 8.—Observed and expected frequency distributions of distance coefficients from the mosquito study of Rohlf (1962). *a*. Upper graph shows observed distribution for distances based on characters that had not been standardized. *b*. Lower graph shows distances based on standardized characters. Abscissas give magnitude of the distances, ordinates indicate frequencies. Solid lines represent observed frequencies, dashed line represents the expected distribution based on the assumptions stated in the text.

with unit variance (Kendall and Stuart, 1958, p. 373). Within the range of the observed d's, and for large n, this is practically a linear transformation.

Under the above assumptions the expected value of d has been shown by Rohlf (1962) to be (for n even)

$$E(d) = \frac{(n-1)!}{\left[\left(\frac{n}{2}-1\right)!\right]^2 2^{n-2}} \sqrt{\frac{\pi}{n}}.$$

Using Stirling's formula, this reduces to:

$$E(d) = \sqrt{2}\left(1-\frac{1}{n}\right)^{\frac{1}{2}}\left(1+\frac{1}{n-2}\right)^{n-1}\frac{1}{e}.$$

Hence:

$$\lim_{n\to\infty}\left[E(d)\right] = \sqrt{2}.$$

For $n = 122$ and $n = 148$, the numbers of characters in the bee and *Aedes* studies, the expected values for d are 1.411 and 1.412, repectively. The observed means of the distances are 1.391 and 1.383, respectively, and thus are smaller than the expected values.

The expected variance of d is:

$$\sigma_d^2 = 2 - [E(d)]^2$$

which approaches zero as n tends to infinity.

For $n = 122$ and 148, $\sigma_d^2 = 0.009$, and 0.006, which are much smaller than the observed variances, 0.0660 and 0.0864, respectively.

Sokal (1961) stated that the expected value of d would be 1.12 [1.128] for any n. He based this on the expected value of the absolute difference between two standardized normal variates. However, d is the square root of the mean *squared* difference and not the *arithmetic mean* of absolute differences which would have an expected value of approximately 1.128, since the expected value of the absolute difference is $2\sigma/\sqrt{\pi}$ (Kendall and Stuart, 1958).

Figure 9 shows the two-way frequency distribution of the distances based on unstandardized and standardized characters for each pair of mosquito species. Each point represents a pair of species. The main effect of standardization was to raise both the mean and the standard deviation of the distance coefficient. This can be explained by the fact that most of the characters used had standard deviations less than unity. The scattergram looks considerably more linear than did the similar scattergrams for correlation coefficients (Figs. 4 and 5). This close relation between distances based on standardized and unstandardized characters ($r = 0.91$) can be explained simply, since changing the origin of the character axes does not change the distance between OTU's. Differences in the values of the distances after standardization are functions of changes in the variances of the characters upon standardization. These differences are expected to be quite minor and were definitely so in the mosquito study. From these results it would seem that for purposes of numerical taxonomy there is not much difference between standardized and unstandardized dis-

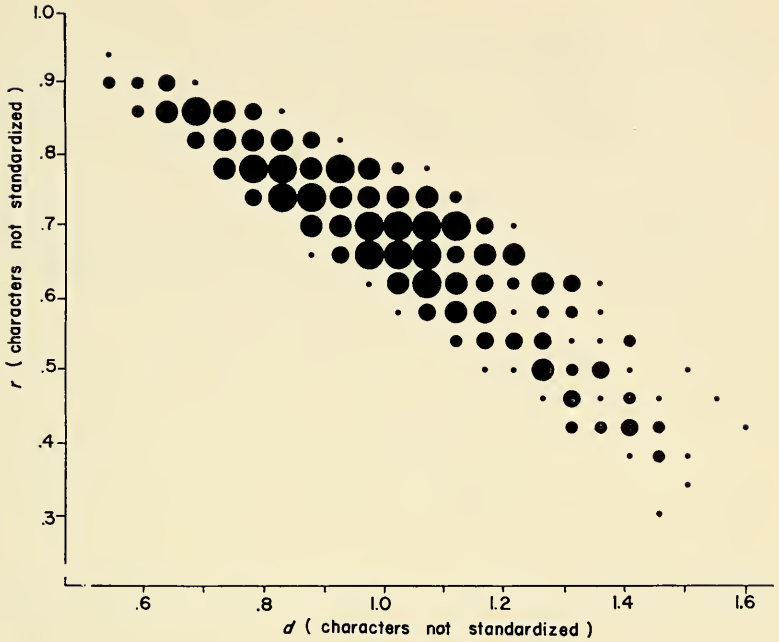

FIG. 9.—Two-way frequency distribution of the distance coefficients based on unstandardized and standardized characters for each pair of species in the mosquito study by Rohlf (1962). Explanations of this figure and scale of solid circles as in Figure 5.

tances. As would be expected, the dendrograms are also rather similar. However, on general principles, distances based on standardized characters are to be preferred. To use unstandardized characters is equivalent to weighting the characters in proportion to their observed standard deviations. It is also of interest to note that even though the largest standard deviation was about one hundred times as large as the smallest, the effect on over-all relationships was very small. This shows that in order to have a strong effect, a system for weighting characters would have to employ an extreme set of weights.

Some further theoretical observations on the distance coefficient and on some other coefficients follow below. The distance coefficient of Sokal (1961) can be easily transformed into the form of a correlation coefficient (r_p, the coefficient of pattern similarity of Cattell, 1949), but no additional information is gained by so doing.

$$r_{p_{ij}} = \frac{\chi^2_n(.50) - nd^2_{ij}}{\chi^2_n(.50) + nd^2_{ij}},$$

where n is the number of characters and $\chi_n^2(.50)$ is the median of

a χ^2-distribution with n degrees of freedom. This coefficient must be used on standardized characters. Within the range of distance coefficients observed in numerical taxonomic studies, and for large n, there is practically a linear relationship between d and r_p; hence, dendrograms based on the different indices would be essentially identical.

Penrose (1952) shows how the distance coefficient can be partitioned into "size" and "shape" components which are supposed to give the relative contributions of these factors to the difference between two OTU's j and k. These components are:

$$(Size)^2 = \left[\frac{\sum_{i=1}^{n}(X_{ij} - X_{ik})}{n}\right]^2$$

$$(Shape)^2 = d^2 - (Size)^2 = \frac{\sum_{i=1}^{n}(X_{ij} - X_{ik})^2}{n} - \left[\frac{\sum_{i=1}^{n}(X_{ij} - X_{ik})}{n}\right]^2$$

with symbols defined as before. As can be seen, $(Shape)^2$ is the variance of the differences between OTU's j and k and will be zero, *i. e.*, indicating identity in "shape" only if the difference between the two OTU's is constant for all of the characters. Hence, this is a measure of similarity in over-all shape only if the character state codes for an OTU are all equal or if the OTU's are identical in both size and shape. For example, consider Table 2 which is based on hypothetical data. OTU's 3 and 4 would have identical shapes by Penrose's "shape" coefficient, but 1 and 2 would not, even though the character state codes of OTU 2 are simply twice that of OTU 1.

TABLE 2.—Matrix of Hypothetical Data.

CHARACTERS	OTU's				
	1	2	3	4	5
1	1	2	2	4	2
2	2	4	2	4	3
3	3	6	2	4	4

OTU's 1 and 5 would also be indicated to be identical in shape despite the fact that they are not of the same proportions. The

product-moment correlations correctly indicate that OTU's 1 and 2, but also 5, have the same "shape." The correlation between OTU's 3 and 4 cannot be calculated because their variances are zero. This would indicate that in most cases the correlation coefficient is an adequate measure of similarity in "shape" since (1) it is very unlikely that an OTU would have identical character state codes for all of its characters, and (2) using standardized characters the means of the OTU's will usually be close to zero; hence, the regression lines will pass close to the origin so that cases such as OTU 1 versus 5 are not likely to occur very often.

The consideration of size and shape is an important one in numerical taxonomy. If most of the characters used in a study are measurements of various parts of an organism, and if the OTU's differ much in over-all size (measured by the distance of an OTU from the origin), the distance coefficient will be more a measure of similarity in size than a measure of similarity in shape, the latter probably being more important for estimating over-all similarity in numerical taxonomy. A dendrogram constructed from such a study would group morphologically small OTU's with small OTU's and large OTU's with large OTU's. This, in most cases, would be very unsatisfactory for constructing a "general classification." With data of this sort, correlation coefficients or special coding of the characters (see below) would seem preferable. This type of effect is also to be considered with meristic characters, although in this case there is less certainty as to what "size" represents. Rohlf (1962) reported such a "size" effect among his larval relationships. Distances showed species 47 and 48 to be much more different from the rest of the species than was shown by the correlations. It appears that there may have been a general "size" effect in these two species that caused many of their setae to become highly branched, the relative numbers staying about the same. In a sense, to say that there is a general size effect is mathematically the same as saying that the characters are, in general, highly correlated. From these observations it might be possible to suggest as a working guide, until a more rigorous mathematical treatment is made of this problem, that whenever the characters seem highly correlated, either correlation coefficients should be used or, before distances are used, the characters should be converted to ratios of some sort in order to eliminate as much correlation between characters as possible. When there is a mixture of types of characters, as is usually the case, it is difficult to say what the best procedure would be.

Cattell (1949) suggests using r_s as a measure of similarity in shape regardless of level, where

$$r_{s_{jk}} = \frac{\sum_{i=1}^{n} X'_{ij} X'_{ik}}{n s_j s_k};$$

n are the number of characters, X'_{ij} and X'_{ik} are the standardized (by characters) character state codes for OTU's j and k, and s_j and s_k are the standard deviations of OTU's j and k. However, since the values are not standardized by OTU's this is not really a pure measure of similarity in shape. There is still some "size" left in it. In order to get rid of this, one has only to use a correction factor to adjust for the differences in the means of the two OTU's. When this is done, $r_s = r$, the product-moment correlation coefficient.

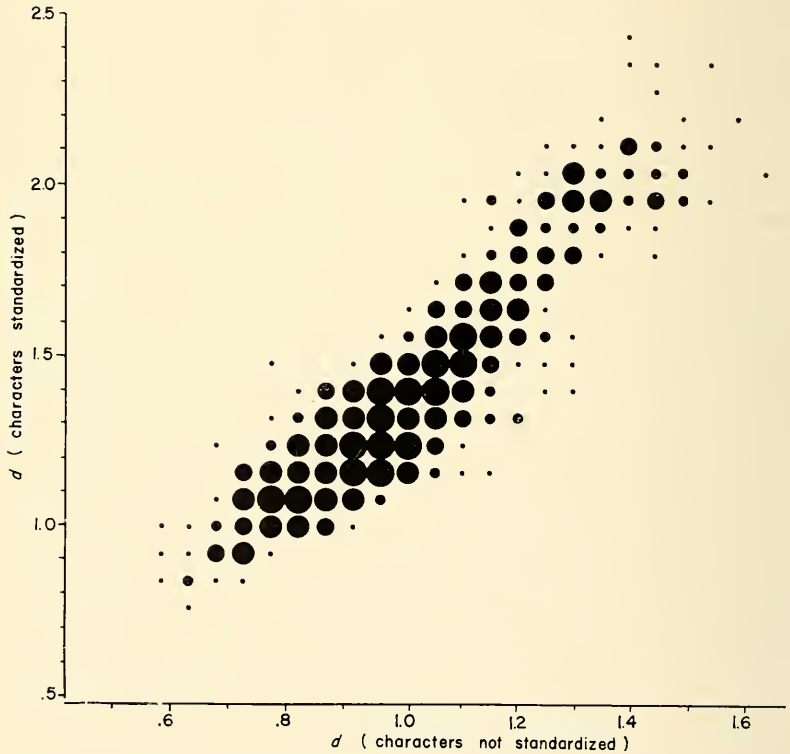

FIG. 10.—Two-way frequency distribution of correlation and distance coefficients for each pair of species in the mosquito study by Rohlf (1962). Both coefficients of similarity are based on characters that had not been standardized. Explanations of this figure and scale of the solid circles as in Figure 5.

c. Comparisons between correlation and distance coefficients

As can be seen from the two-way frequency distribution of correlation and distance coefficients of *Aedes* based upon unstandardized data (Fig. 10) these two coefficients indicate very similar relationships among the species of mosquitoes. The correlation between these two coefficients is –0.92 and an inspection of the figure reveals that the relationship is a linear one.

The two-way frequency distribution for distance and correlation coefficients based on standardized data indicated lower correlations between the two coefficients in the bees (Fig. 11) and especially in the mosquitoes (Fig. 12). The observed correlations were –0.77 and –0.52, respectively. The species in the sub-genus *Stegomyia* and a few other species were much more different from the rest of the species in the study when measured by distance coefficients than when measured by correlation coefficients. This may have caused the much lower correlation in the mosquito study. In Fig-

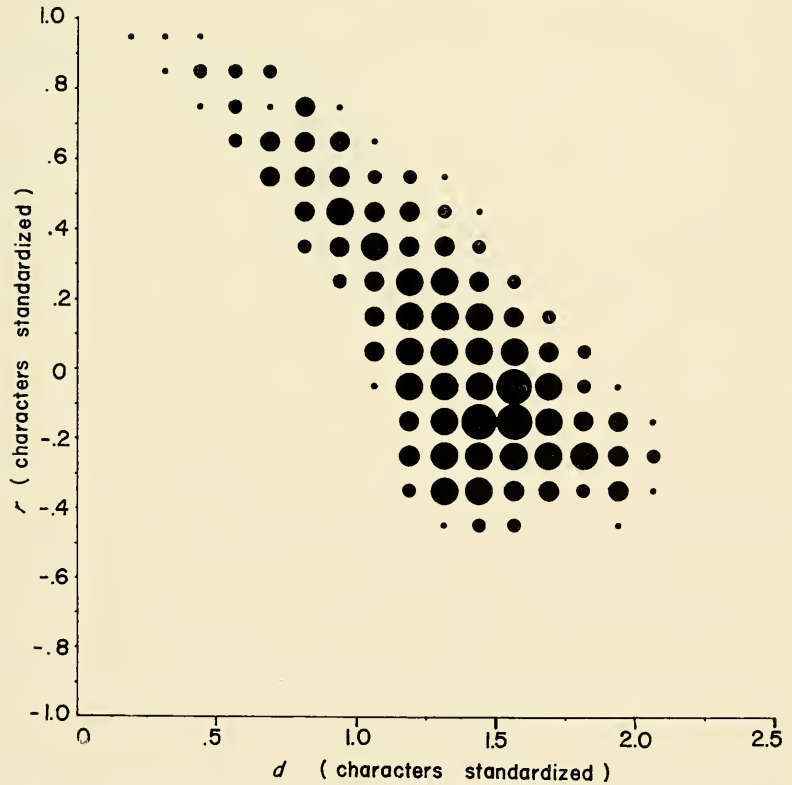

FIG. 11.—Two-way frequency distribution of correlation and distance coefficients for each pair of species in the bee study by Michener and Sokal (1957). Both coefficients of similarity are based on standardized characters. Explanations of this figure and scale of the solid circles as in Figure 4.

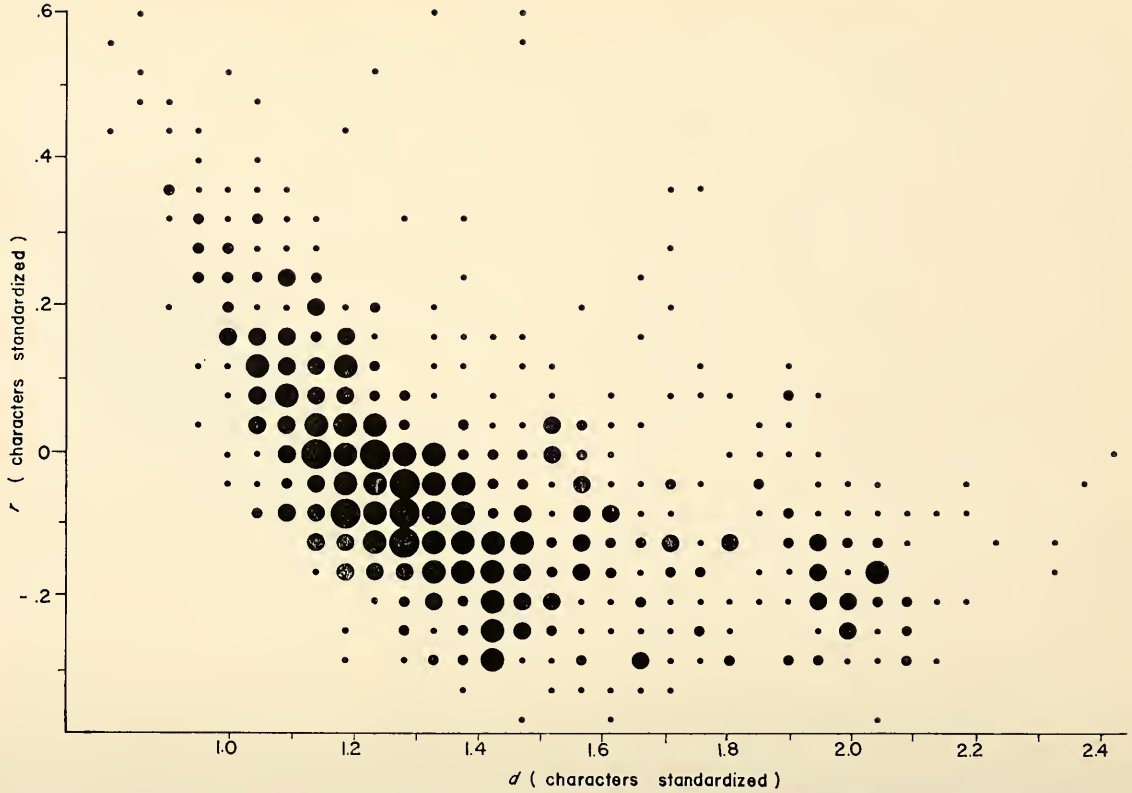

FIG. 12.—Two-way frequency distribution of correlation and distance coefficients for each pair of species in the mosquito study by Rohlf (1962). Both similarity coefficients are based on standardized characters. Explanations of this figure and scale of the solid circles as in figure 5.

ure 12 this can be seen by the presence of a secondary mode on the right side of the two-way frequency distribution. These deviant species seem to differ from the rest more in "size" than in "shape." Since the majority of the characters used in the mosquito study cannot be interpreted, even indirectly, as a measure of "size," it is difficult to interpret the meaning of the "size" component in this study. Its presence is indicated by the fact that there is a difference between those relationships indicated by correlation coefficients and distance coefficients.

V. SUMMARY OF RECOMMENDATIONS

It is recommended that, except in studies based upon characters whose states cannot be linearly ordered, the characters should be standardized by transforming all characters in a given study to a comparable scale. It is suggested that a transformation be used so that each character will have a mean of zero and a standard deviation of unity. It is also recommended that if most of the characters used in a study are measurements of various parts of an organism, and if the OTU's differ much in over-all size, then correlation coefficients should be used as measures of taxonomic similarity. If the characters can be converted to ratios independent of size then distance coefficients can be used. If there is a mixture of types of characters then it is difficult to say what the best procedure would be. Until more experience is gained on this point, we would suggest that both coefficients should be computed and comparisons made, since both are valid measures of similarity.

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The Generic Relationships of the Family Pyemotidae (Acarina: Trombidiformes)[1]

BY

EARLE A. CROSS [2]

ABSTRACT: The tarsonemine family Pyemotidae includes a group of over a hundred and twenty known forms, some of which are of medical or agricultural importance. It is thought that only a small fraction of the species are known. The purpose of this study is to add to and synthesize the present knowledge of the history, sytematics, morphology, distribution, habits, and phylogenetic relationships of the group. Classification is largely done at the supraspecific level, species usually being described only as types of the higher categories.

The family is divided into 3 subfamilies, one of which (Pygmephorinae) is further separated into 3 tribes. Twenty-nine genera and subgenera are described as new or redescribed as follows: *Dolichocybe, Pavania, Pyemotes, Caraboacarus, Paracarophenax, Acarophenax, Adactylidium, Trochometridium, Siteroptes* (*Metasiteroptes*), S. (*Siteroptes*), S. (*Siteroptoides*), *Resinacarus, Pediculaster* (*Pediculaster*), *P.* (*Acarothorectes*), *Pygmephorus, Microdispodides, Microdispus* (*Premicrodispus*), *M.* (*Microdispus*), *Myrmecodispus, Glyphidomastax, Perperipes, Peponocara, Parapygmephorus* (*Sicilipes*), *P.* (*Parapygmephorus*), *P.* (*Petalomium*), *Acinogaster, Pseudopygmephorus, Neopygmephorus* (*Neopygmephorus*), *N.* (*Allopygmephorus*).

Sixteen new species are described: *Paracarophenax dybasi, Adactylidium beeri,* S. (*Metasiteroptes*) *macer,* S. (*Siteroptoides*) *absidatus, Trochometridium tribulatum, P.* (*Acarothorectes*) *curculionium, Microdispodides pholidotus, M.* (*Premicrodispus*) *chandleri, Myrmecodispus dorylinis, Glyphidomastax rettenmeyeri, Perperipes ornithocephala, Peponocara cathistes, P.* (*Sicilipes*) *halictinis, P.* (*Parapygmephorus*) *natalensis, P.* (*Petalomium*) *krczali, Acinogaster marianae.*

1. Contribution No. 1173, Department of Entomology, The University of Kansas. A portion of this work was financed from The University of Kansas General Research Fund, Project No. 4513-5570.

2. Present address: Northwestern State College, Natchitoches, Louisiana.

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INTRODUCTION

The purpose of this paper is to add to and synthesize the knowledge of the systematics, morphology, habits, and phylogenetic relationships of this little-known group of mites.

This paper represents the second major revision of the family, being preceded by the excellent monograph of Krczal in 1959. It should perhaps be pointed out here that the two papers evolved nearly entirely independently and it is therefore a pleasure to note the many points of agreement between them. Every effort has been made herein to correctly credit those ideas originating with the former author. In a real sense, the two works complement one another, Krczal's stressing work at the species level, this paper being more concerned with higher categories.

The family is here divided into 22 genera, these further divided into 29 subgenera and approximately 120 species. This evaluation was made after the inspection of approximately 2400 slide-mounted specimens and on the basis of a careful survey of the literature.

In contrast to that of the Tarsonemidae, the classification of the members of this family is based primarily on the females, a circumstance resulting from the relative availability of the sexes. In at least the lower forms (*Pyemotes, Siteroptes, Acarophenax, Paracarophenax*) this is due not only to the sex ratio (five to ten percent males) but also to the transience of the males.

Because only a fragment of the total fauna is known and because of the relative scarcity of long series, satisfactory definition of both species and higher categories is sometimes quite difficult. In all cases categories have been defined using as many characters as possible, thereby placing a minimum of reliance upon so-called "weighted" characters. The limited use of such characters has been unavoidable, however, since the author has preferred to erect a phylogenetic as opposed to a "static" (in the sense employed by Sokal *in* Michener and Sokal, 1957) classification or one based upon "overall basic similarity" (Bigelow, 1958). Data are presently

being gathered in order to compare such a classification with the one presented herein.

Both the size of the morphological gaps between species and the number of species included in a group were considered in erecting taxa. The establishment of monotypic genera was avoided except in cases (*e. g., Glyphidomastax*) in which the monotypic form showed an unusual amount of morphological isolation.

Certain genera, notably in the Neopygmephorini, are difficult to define because of the continuum of characters occurring between the various species. As pointed out by Michener (1944), however, such conditions are to be expected among continually evolving species groups and do not necessarily invalidate the classification.

Any specific characteristic, morphological or otherwise, which varied among species, was considered to be useful as a "taxonomic character."

Variation. A great amount of variation in size is present in both sexes, this reflecting itself in various body and setal dimensions. At least the latter may vary independently, *e. g.*, the dorsal setae of female *Trochometridium* are nearly equal in size although the largest specimen is a third bigger than the smallest.

Interpopulational variation in size does not differ markedly in extent from intrapopulational variation insofar as it is possible to judge. The author has often observed phoretic females of pyemotids or scutacarids from the same host specimen, therefore presumably from the same population, to differ greatly in this respect. In the case of the scutacarid *Imparipes americanus* Banks, such variation was seen to occur within the single earthen cells of certain bees and among individuals that may have been the progeny of one mother. In the same species, which is normally heavily pigmented, whitish or very pale individuals occasionally appear, a phenomenon known to occur in other mites, *e. g.*, Dermanyssidae.

Setal attributes other than size, such as number and location, remain remarkably stable within a species and are therefore used extensively as characters at specific and at higher levels. The variation of certain characters, such as amount of pigmentation, punctation, development of apodemes, etc., is often not useful because it is inseparable from extrinsic variation due to clearing and mounting.

Distribution. The effect of the distribution of pyemotids upon their classification has not yet been evaluated thoroughly. Early acarologists, *e. g.*, Berlese and Jacot, bound by the morphological

species concept, ignored distribution altogether and considered forms from different continents to be conspecific if they were morphologically indistinguishable. Later specialists, aware of criteria of gene exchange in species separation, and certain that oceanic barriers must be limiting, often declared them to be distinct despite supposed inseparability on morphological grounds.

Excluding those species undoubtedly spread through commerce (*e. g.*, grain-inhabiting forms of *Pyemotes* and *Acarophenax tribolii*), it is evident that many, perhaps most pyemotid genera are widely distributed. *Acinogaster,* for example, occurs in Angola and Panamá, and *Neopygmephorus* and *Premicrodispus* are both found in Europe, North America, and Australia. Numerous other examples are available. Widespread distribution of species is seemingly less frequent. Comparison of various North American populations of *Pseudopygmephorus sellnicki* (Krczal) and the scutacarid *Scutacarus acarorum* (Goeze) with the descriptions and statements of variation among European specimens of these forms leads one to conclude that equal or sometimes greater morphological variation may occur in these species between nearby localities than between continents. A similar situation, based upon small sample sizes, seems to exist in certain species of *Premicrodispus* and *Neopygmephorus.*

Within North America, certain forms of *Pediculaster* and *Siteroptes* appear to vary interpopulationally in an irregular and recurring "mosiac" manner rather than in any clinal fashion but the data are too incomplete to permit definite conclusions to be drawn.

Although the vagility of mites is largely unknown, particularly over long distances, it seems certain that they are well represented in the air-borne fauna. Lindroth (1957) states that the microfauna is "above average" in respect to its presence in air samples although he cites no specific data. Gislén (1940) concludes that no geomorphological barriers exist for microscopic and semimicroscopic animals, their distribution being therefore dependent entirely upon ecological factors. Such species are therefore likely to be cosmopolitan within their ecological limits. It therefore seems not at all reasonable to recognize two species as distinct only because of their occurrence on different continents.

My admittedly incomplete data suggest that species in the Pyemotidae can easily be explained by such "continuous" distribution. Such a distribution is obviously of little value in determining the relative antiquity of the various groups.

Life Histories. The following briefly summarizes some aspects of the known life histories of mites in the family. Separate, more elaborate treatments may be found herein following the generic descriptions.

Gravid adult females may (Pyemotinae, Acarophenacinae, some Pygmephorini) become hugely distended and spherical or (most Microdispini, Neopygmephorini) such females may undergo only a slight size increase. Those of the first type usually contain considerable numbers (often over 100) of well developed ova. Females of the latter type rarely contain more than three well developed ova simultaneously.

In some Pyemotinae (*Pyemotes, Trochometridium*) and in the Acarophenacinae, the ova hatch into quiescent, indefinite forms which telescope all immature stages and terminate with the appearance of the adult mite. This development usually occurs within the distended maternal body so that the adult female gives birth to adults of the next generation. Rarely (*Trochometridium*) emergence of a new generation of adults occurs after death and partial decomposition of the mother's body. In *Siteroptes, Resinacarus,* and at least in most Pygmephorinae, a definitive larval stage is present. Except in the first-named genus, this stage is not known to be active and does not hatch from the egg but develops from larva to adult in the manner described for *Pyemotes* (above); however, at least some scutacarid females lay eggs which hatch into active larvae, these soon becoming quiescent and moulting directly to adults. The larvae of *Siteroptes* may hatch and actively move about, sometimes escaping from the body of the mother. Reuter (1900) states (probably erroneously) that a single nymphal stage is present in *Siteroptes.* Nymphal stages are otherwise unknown in the family. Omission of the various definitive immature stages greatly accelerates embryogenesis and, at least in the Acarophenacinae, development from egg to adult may consume only three days.

Birth of the young adults may occur continuously through the vulva (*Pyemotes*) or (probably) continuously through a secondary oviporus (*Perperipes*) or nearly simultaneously in conjunction with the hysterosomal breakdown of the mother (*Siteroptes, Acarophenax, Paracarophenax*).

Females are usually mated immediately after freeing themselves from the enveloping embryonic membranes and often within the body of the mother. In species practicing phoresy, they are the

only known phoretic stage; they probably are responsible for the dispersal of the species in any event.

Unmated females of *Pyemotes* and *Siteroptes* rarely produce offspring; if so, such females are arrhenotokous.

The number of males is small, rarely exceeding five per cent of the total number of offspring in *Pyemotes, Siteroptes, Acarophenax,* and *Paracarophenax.* A higher percentage of males (probably up to 45 per cent) may occur in *Trochometridium.* Males usually complete their development before females and may then be born (*Pyemotes*) or may move about within the body of the mother searching for mates (*Acarophenax, Paracarophenax,* usually *Siteroptes*). In the latter case they may initiate or accelerate the hysterosomal breakdown resulting in the mass birth of the enclosed mites. Males of *Pyemotes* remain in the vicinity of the vulva after they are born and copulate with the females as they emerge. Such males may actually assist in the birth of the females by pulling them through the birth opening. They seemingly are parasites upon the body of the mother mite and die quickly if removed therefrom.

Food habits of known species are variable although generally constant at the generic level. *Siteroptes* and *Resinacarus* are probably fungivorous, *Pyemotes* is a parasite of various immature insects, *Trochometridium* is known thus far only as a parasite of larval Apoidea, and *Acarophenax* and *Paracarophenax* are egg parasites of beetles. To judge from morphological specializations and from collecting data, it is likely that *Glyphidomastax* and *Perperipes* are parasites of immature doryline ants and that most members of the Neopygmephorini are scavengers or fungus feeders.

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G. W. Krantz, Oregon State University, Corvallis; G. Lombardini, Florence, Italy; H. B. Morlan, Pensacola, Florida; A. E. Pritchard, University of California, Berkeley; C. W. and M. E. Rettenmeyer, Kansas State University, Manhattan; G. W. Wharton and D. E. Johnston, Ohio State University, Columbus.

Dr. H. F. Stammer, University of Erlangen, Erlangen, Germany kindly loaned an unpublished manuscript concerning mites of the family Scutacaridae. This manuscript has since been published (Karafiat, 1959).

Diane A. Hanson of The University of Kansas and David T. Henry of Northwestern State College inked and otherwise ably assisted with the illustrations. Dorthy S. Cross typed the manuscript and Sylvan W. Nelken and Charles H. Wommack of Northwestern State College otherwise assisted in its preparation.

TECHNIQUES AND PROCEDURES

Collecting. Many species of pyemotids are found in moss, grass, litter, mammal and bird nests, humus, punky wood, and in other forms of vegetation, living or dead. Such specimens are collected into 70 per cent ethyl alcohol from a berlese funnel. The bodies of various insects are also good sources of material. Mites from these may be removed to alcohol with various moistened implements. Dead specimens from such sources are extremely fragile and should be relaxed before removing.

Freshly-killed vertebrates were first chilled then washed in the manner used by Lipovsky, Crossley, and Loomis (in litt.), a method which proved quite successful in the recovery of certain pygmephorines.

A fine camel's hair brush is useful in the handling of living material.

Mounting. Various methods of clearing and mounting were attempted. The two which proved most satisfactory were, (1) clearing in lactophenol and mounting in polyvinyl alcohol-lactophenol (PVA) as described by Lipovsky (1953), and (2) clearing in glacial acetic acid-chloral hydrate solution and mounting in Hoyer's medium. Providing the mount is not overly thick, the latter medium seemingly possesses the most desirable optical properties and, in addition, allows the preparation of excellent mounts if the specimen is gently heated after the application of the cover slip. It has the disadvantage of crystallizing in a short period of time, particularly in relatively dry climates.

Mites mounted in PVA are relatively more permanent but are less desirable for study than those in Hoyer's medium and do not seem to expand as well when heated.

Viewing. Observations and dissections were made of living specimens as well as specimens preserved in 70 per cent ethyl alcohol and in Carnoy's fixative. The latter proved excellent as a preservative for gross dissections, but dissected parts often proved difficult to clear for observation under high magnification. A similar difficulty was met while attempting to clear certain specimens preserved for long periods of time in ethyl alcohol.

A Leitz binocular microscope having a maximum power of 216 magnifications was used for the above dissections and gross observations. Slide mounts were observed using a phase microscope having a maximum magnification of about 1450 diameters. Most study was done at 970 $\times$ and 1450 $\times$.

Measurements. Measurements were taken with a .1-mm. grid micrometer placed within a 10 $\times$ ocular and were made under the highest magnification possible, 430 or 970 $\times$, depending upon the size of the structure involved. Estimations were made to the nearest tenth of a grid square. Independent measurements of the same specimens, repeated later, suggest that the extrinsic error involved is about $\pm$ .2 of a square ($\pm$ 5μ at 430 $\times$, $\pm$ 2μ at 970 $\times$).

The mean was obtained for all measurements in cases where $n \geqslant 5$; its standard error was calculated only in those cases where $n > 10$.

The various measurements were as follows:

1. Length of body: Along sagittal line from anterior margin of propodosoma to posterior margin of hysterosoma.

2. Width of body: Widest point of hysterosoma measured along transverse axis of body.

3. Length of gnathosoma: Along sagittal line from palpal apex (palps in folded position) to posterolateral condylar processes.

4. Width of gnathosoma: Widest part of gnathosomal capsule measured along a transverse axis.

5. Distance between internal pseudostigmatal sockets: That between centers of origin of pseudostigmatal pedicels.

6. Lengths, legs I to III: Along longitudinal axis of leg from most basal point of trochanter to base of claw(s).

7. Length, leg IV: Along longitudinal axis of leg from most basal point of coxa to base of claws. Because of the curvature of these legs in the more specialized genera this measurement was often divided into two or more sections.

8. Lengths, leg segments: Greatest possible measurement along longitudinal axis of segment. Tarsal measurements exclude claw(s) and pulvillus.

9. Width, trochanter: Measured along transverse axis at apex of trochanter.

10. Width of coxa IV: Width along transverse axis at medial coxotrochanteral condyle.

11. Distances between setae are measured as the distances between the centers of the areoli.

12. Distances between apodemes I and II, and between apodemes II and the posterior marginal apodemes, are measured along the anterior median apodeme.

Other measurements (*e. g.*, that between the anterior sternocoxal condyles of coxae III) are self-explanatory, or are used only rarely and explained at the place of their appearance in the text.

In addition to the errors in measurement due to estimation (see above) certain other sources of extrinsic error should be mentioned. Perhaps the most obvious of these is the distortion of body shape that occurs in preparation of a slide mount. Such distortion is perhaps greatest in width, but is also considerable in length, the more so because of body segmentation in the species concerned. A second source of distortion is due to the position of the mite on the slide, this distortion often imparting an incorrect impression of the shape, size, or location of the structure concerned. Other sources of error may be due to differences in type and amount of clearing and in the kind of mounting medium. Differences in appearance caused by any of the above may overlap natural differences, thus making the detection of intrinsic variation difficult. Of course every effort has been made to take into consideration artificially produced differences and to recognize the naturally occurring differences.

Because they serve as a classificatory framework in a poorly-known group, generic descriptions are purposely overdetailed. This detail should be of assistance in pointing out characters of value to future workers.

The descriptions of new species are based upon the type specimens, variation encountered within the type series being indicated in parentheses.

Structures were drawn to scale but setal lengths and thicknesses were estimated and the reader is referred to the descriptions for detail. In a few cases where they could not be included without causing probable misinterpretation, one or more tarsal setae have been omitted from the illustrations of whole mites. Such omissions will not hinder identification of the forms concerned. All setae have been illustrated in the separate, enlarged drawings of tarsi.

For those forms in which the types were not available and which

were inadequately described, the author has purposely tended toward conservation in the retention of species names, hoping thereby to keep nomenclatural confusion to a minimum. The reader is referred to the species lists following each generic description for generic assignments of species.

THE FAMILY PYEMOTIDAE: HISTORY

Although the family was not formally recognized by Berlese until 1898, certain species now placed in the genus *Pyemotes* were among some of the earliest known acarines. The distinctive, enormously gravid females were noted by Hartig (1834), von Heyden (1835), and DeFilippi (1861) on larval Hyemoptera and by Debey (1849) on larval Coleoptera. Many other authors reported them as parasites of various insect larvae, sometimes because they proved extremely destructive to cultures of species under investigation (Lichtenstein, 1868, 1869, 1875).

Closely related species were found, at about the same time, to cause the urticarioid dermatitis widely known among workers with stored grains in central Europe and America and commonly referred to in this country as the "grain itch." Perhaps the first association of this affliction with mites was made in 1838 in France by P. Debia, who incorrectly assumed it to be caused by a mite belonging to the family Acaridae. A large amount of literature has been and continues to be concerned with the medical importance of members of the genus *Pyemotes*.

As mentioned by Beer (1954), various authors have disagreed on relationships between tarsonemoids and other mite groups. With few exceptions these disagreements have been between those authors believing them to be most closely related to the sarcoptiforms and those believing them closer to trombidiform types. The following account briefly states the historical development of classification in each of the two groups.

Newport placed his *Heteropus* (1850) in the family Sarcoptides Latreille. In 1877 Kramer erected the family Tarsonemidae to include the single genus *Tarsonemus* Canestrini and Fanzago, 1876. This family was placed in his Acarina Tracheata. In 1880, R. Canestrini placed *Pygmephorus* Kramer, 1877, in his family Oribatidi, considering the Tarsonemidae to be a separate sarcoptiform subfamily. This system was followed by Michael (1880) and by Haller (1881 and 1882). Berlese (1885) was the first to recognize the close relationship between *Tarsonemus* and *Pygmephorus*, plac-

ing them, together with *Disparipes* (= *Scutacarus*) in the subfamily Tarsonemidi of his family Oribatidi. The following year he became aware of *Pediculoides* Targioni-Tozetti, 1878, and after giving a history of the genus (= *Heteropus* Newport, 1850, = *Sphaerogyna* Laboulbène and Megnin, 1885) added it to the Tarsonemidi. He regarded the subfamily as transitional between his Oribatidi and Sarcoptidi because of the pseudostigmata, the strong ventral apodemes, and (mistakenly) a ventral genital opening. In 1895, 1897, and 1898, the same author realized the distinctness of the group and placed it in a separate suborder, the Heterostigmata, this suborder to consist of species in which only the females possessed stigmata. Later in 1898 he separated the Pediculoididae (= Pyemotidae Oudemans, 1937) from the Tarsonemidae, the former to include *Pediculoides*, *Pygmephorus*, and *Podapolipus* Rovelli and Grassi, 1888. His 1925 classification is similar except that he has followed Paoli (1911) in removing the genera *Disparipes*, *Diversipes*, and *Imparipes* to the family Disparipedidae (= Scutacaridae Oudemans, 1917). The principal supporters of the earlier views of Berlese were Banks (1905a, 1915), and Ewing (1909, 1929, and 1939; *vide* Beer, 1954).

Laboulbène and Megnin (1885b) described *Sphaerogyna* as a new name for *Heteropus* Newport, at the same time giving the first resume of the history of the genus. They placed it in the family Trombidiés near the tribe Cheyletides because of the structure of the gnathosoma and palps, the styliform chelicerae, and the positions of the legs. Similar systems were followed by G. Canestrini in 1888 and 1891, and by Trouessart (1896). The latter, on the basis of chelicerae, palps, and (erroneously) the male genital opening, placed the group as the section Tarsonemeae of his subfamily Cheyletinae.

Brucker (1901) used characters of the chelicerae, integument, and internal anatomy (the latter largely from the midgut and tracheae) as well as habits to erect a classification roughly parallel to that of the two preceding authors. In 1909, Reuter used essentially the same characters to erect the subordinal classification in use by most authors today. Within this classification tarsonemines were placed in the single family Tarsonemidae of the superfamily Trombididoidea.

Vitzthum (1929) recognized the three tarsonemine families of Berlese (1925), placing them in his supercohort and cohort Tarsonemini of Reuter's Trombidiformes. Oudemans (1931) removed

Podapolipus and several related genera to form a fourth family, the Podapolipodidae, otherwise retaining the classification of Vitzthum. Since 1929 no important change in classification has been made, although important papers have been written on the group by Vitzthum (1943), Baker and Wharton (1952), Beer (1954), Cunliffe (1955), and Krczal (1959b).

A unique classification, based solely upon stigmatal position, was proposed by Oudemans (1906). In this scheme the family Tarsonemidae formed a single group, the Trachelostigmata, closely related to both the Antistigmata (including the Uropodidae and Holothyridae) and the Stomatostigmata (including the single family Labidostomidae). This classification has been largely ignored by succeeding authors.

Excellent accounts of the history of the generic name *Pyemotes* were given by Oudemans (1936, 1937a).

COMPARATIVE MORPHOLOGY

Because of the lack of prior studies within the families of the Tarsonemoidea, the following section is offered, not as a principal area of investigation, but as a guide for more serious students of morphology.

The studies described below are limited to members of the family Pyemotidae, but there is little difference between the more specialized neopygmephorine members of this family and members of the family Scutacaridae and the following observations therefore are pertinent to the consideration of either family.

FEMALE

Gnathosoma

The anteriormost division of the body is the gnathosoma, a capsular structure probably derived from both palpal and cheliceral sources. In most pyemotids, as in the other Tarsonemoidea, it is free, protruding from and articulating basally with the propodosoma. In the more specialized genera of the Acarophenacinae, however, it is contained completely within and protrudes only slightly or not at all from the anteroventral portion of the propodosoma (figs. 43-50). In order to simplify the presentation of the following observations, these specialized acarophenacines will be dealt with separately following the discussion of the more ordinary forms.

Forms with gnathosoma free. In these forms, the gnathosoma is typically prognathous except in *Peponocara* and *Caraboacarus* (figs.

41 and 78) in which genera the lateral and anterior margins of the gnathosomal capsule are expanded ventrally to displace the trophi. In *Caraboacarus,* this displacement is only slight but it is pronounced in *Peponocara, P. cathistes* appearing distinctly hypognathous.

In dorsoventral aspect, the gnathosomal capsule (figs. 1, 2) is a variably shaped (globose, quadrate, rectangular, or ovoid) structure, its basal margin well sclerotized and produced lateroventrally into a pair of condylar processes. Probably only dorsoventral movement of the gnathosoma upon the propodosoma is possible. A dorsal, longitudinal, median apodeme may join the posterior margin, extending anteriorly for varying distances. The dorsal and ventral surfaces of the capsule extend anteriorly between the palpi and enclose the mouth parts from above and beneath.

Dorsally, the gnathosomal capsule usually bears two pairs of setae, the *internal* and *external dorsals* (fig. 1), of which the internals are always the most anterior. In *Pyemotes* and in *Dolichocybe* these setae arise well forward, the internals well in front of or in line with the second palpals. In all other genera the internals are posterior to the second palpals. In *Caraboacarus* and in certain species of the Pygmephorinae the external dorsals appear on the ventral surface. In *Microdispus* (*Premicrodispus*) the internal dorsals may be absent, and in at least one species of *Pygmephorus* both pairs of dorsals are lacking.

Arising laterally or dorsolaterally behind the palpi there may be one or two pairs of *postpalpal setae.* These usually lack distinct areoli and may be hidden along the lateral gnathosomal margin. They are especially difficult to see in certain *Pseudopygmephorus* and may be lacking in some *Premicrodispus.* Ventrally, a single pair of *gnathosomal ventrals* (fig. 2) usually arises from the anterior half of the gnathosoma. *Trochometridium* and *Caraboacarus* have a second pair of gnathosomal ventrals, those of the latter genus being heavily sclerotized and spheroid in shape.

In most prognathous forms (exception, *Pavania*) the palpi arise from lateral excavations of the gnathosomal capsule, their lateral margins forming a continuous line with the lateral margins of the capsule. They enclose the trophi at the sides. Basally they articulate with the capsule, being capable of at least lateral-mesal movement in all genera except *Pyemotes* and *Caraboacarus,* in which they are inarticulate and at least partly fused to the wall of the gnathosoma (Krczal, 1959, states that the palpi of *Pyemotes* are distinct

and "slightly movable" but I am unable to discern either free margins or articulations in the specimens available to me). In these genera the line of fusion is more or less distinct and both pairs of palpal setae are retained. In *Pavania,* the palps are free and arise from the ventral surface of the capsule.

In forms having free palpi, these appendages are usually at least slightly palmate and possess one or more apical teeth. The teeth usually arise from the medioventral surface of the palp and may be free and seemingly movable (*e. g., Pygmephorus*) or fused to the palpal apex. In *Dolichocybe* and in some *Neopygmephorus* (fig. 2) the palpal teeth may be replaced by a clawlike hook. They are reduced in *Dolichocybe* and *Trochometridium* and absent in *Pyemotes* and *Caraboacarus.* In *Dolichocybe,* the palpi are subcylindrical, while in *Glyphidomastax, Perperipes,* and some *Myrmecodispus* they are greatly elongate and sharp.

In all forms seen by this author the palpi are one-segmented although in some forms (fig. 2) suturelike lines may occur on one or more surfaces. Oudemans (1931) mentions, probably mistakenly, forms with two palpal segments. The palps of *Pygmephorus thienemanni* Willmann (not seen by this author) are said to possess four segments; this form is seemingly highly specialized in other respects.

Universally present in all forms having a free gnathosoma, and arising from the dorsolateral, lateral, or ventrolateral margins of the palpi, are the conspicuous *first* and *second palpal setae,* the former the most basal. These often appear to divide the palps into three subequal areas, and, because of their constancy in location, may provide information concerning areas of differential growth. In addition, the inner apical surface of the palp may possess one or two tiny setae, these not always visible. Arising from the ventral surface of the apical half in many forms are *palpal solenidia 1* and *2.* The latter is atypical in appearance, being non-striate. It may be cylindrical, clavate, capitate, cuspidate, or concave apically, and is nearly always much larger than solenidium 1. The latter is typically striate and arises lateral or posterolateral to 2. In *Pavania, Pyemotes,* and *Trochometridium,* at least solenidium 2 is reduced and may be indistinct. In *Caraboacarus, Perperipes, Glyphidomastax,* and some *Myrmecodispus,* the palpal solenidia may be lacking. Palpal setation frequently offers specific characters, particularly as regards shape and placement of the various setae.

The palps probably function in most forms to anchor the mite to the substrate while it feeds.

The trophi were not studied intensively for purposes of this work and the following brief account is taken largely from the excellent work of Krczal (1959b) and refers to *Pyemotes.*

The chelicerae are dorsal, their distal portions styletlike, their bases guttate, recurved laterally, housed in anterodorsal pockets which may appear broadly tuberculate upon the dorsal surface of the capsule. Their guttate bases are prominent landmarks of the gnathosoma, often visible when the sylets are indistinct. At least in *P. scolyti,* the chelicerae are separated by a longitudinal dorsoventral septum and bounded dorsally and ventrally by chitinized plates. The styli are independently protracted or retracted by muscles originating basally (protractors) or laterally (retractors) from the capsular wall and inserting basally (protractors) and distally (retractors) upon the cheliceral base ("*Stechborstenhebel*" of Krczal). Beneath the cheliceral opening lies the oral orifice, enclosed apically in an acuminate cone. This cone is inserted into the wound made by the chelicerae once the latter are withdrawn, and the sucking operation commences. The oral cone is contiguous with an enlarged, ovoid, ventral esophageal-pharyngeal pump ("pharynx" of authors). Brucker (1901), in describing the operation of this pump, states that it expands slowly, then contracts quickly to push the liquid food into the gut. Contractions were noted to be on the order of about 50 per minute. With certain modifications, the foregoing is probably similar to the structure and function of the mouthparts of most Pyemotidae. The chelicerae are enlarged and falcate in *Pavania,* often bladelike in *Pyemotes, Trochometridium, Pepoponocara,* and in all genera of the Acarophenacinae, but are smaller and usually indistinct in all remaining genera. It should perhaps be mentioned that with the exception of *Pyemotes,* all those forms with enlarged chelicerae are phoretic upon the adults of (and probably parasites of the immature stages of) various insects. The seemingly rare occurrence of phoresy in species of *Pyemotes* correlates well with the broad host tolerance seemingly characteristic of that genus.

The ovoid esophageal-pharyngeal pump is reduced in *Dolichocybe* and absent in all other genera possessing a free gnathosoma. In these latter the flexible esophagus is usually visible posterior to the chitinized buccal chamber. Within the gnathosoma, it may be

straight or characteristically looped, coiled, or spiralled. In the Pygmephorinae, a pair of small, globular or elongate structures are often found adjacent to the esophagus. They appear to connect to it and perhaps are salivary glands. In the Pygmephorini and Neopygmephorini a narrow "finned structure" in the shape of a bow-tie may be visible. If present this structure is always followed by one or two similar structures located in the propodosoma. These will be mentioned in more detail later. The supra- ("*Chitinspange*") and sub-cheliceral plates ("*Chitinplatte*") of Krczal assume varying shapes or are absent in genera other than *Pyemotes.*

Gnathosoma hidden. In *Acarophenax, Paracarophenax,* and *Adactylidium* (figs. 43-50) the gnathosoma is much reduced and nearly or completely enclosed within the propodosoma, with which structure it may be partially fused. Its structure is therefore difficult to ascertain. The palps of such species are not or only partly distinct and setae of the gnathosomal region are lacking except in *Acarophenax,* which possesses one to three pairs. The most prominent gnathosomal structures in these forms are the enlarged, anteroventrally or ventrally directed chelicerae and the esophageal pharyngeal pump, both of which are similar to those described above for *Pyemotes.*

In addition to the above, species of *Paracarophenax* exhibit a unique, elliptical, median ventral structure which may be the paired salivary glands and their heavily sclerotized ducts (the lateral "sclerotized margins" of this structure are indeed tubular). Paired ducts presumed to be salivary are distinct beneath the respiratory system in *Acarophenax* and *Adactylidium.* In the region of the dorsal U-shaped apodeme these fuse, the resulting duct appearing to be suspended from a thin median longitudinal apodeme which may be contiguous posteriorly with the U-shaped apodeme. Anteriorly, this duct bends ventrad to enter the anterior portion of the pharyngeal pump at which juncture it may become campanuliform or otherwise dilated.

Propodosoma

The propodosoma (figs. 3 and 4) is the second body division. Located between the gnathosoma and the hysterosoma, it is the section of the body bearing the first two pairs of legs. Except for the genera *Acarophenax, Paracarophenax,* and *Adactylidium,* which will be discussed later, the propodosoma consists of a single structure which, in shape, may be likened to a sleeveless sweater with four instead of two armholes. In the Pyemotinae, its dorsum is

about as long as the venter, while in the majority of the Pygmephorinae the venter is distinctly longer than the dorsum. The anterior *circumgnathosomal foramen* varies greatly in shape and position, its characteristics greatly dependent upon the manner in which the gnathosoma is normally carried. In those genera (*Pyemotes, Dolichocybe, Caraboacarus*) in which it is directed straight forward, or nearly so, the foramen opens approximately at a right angle to the longitudinal axis of the body. In some *Siteroptes, Resinacarus,* and in most of the Pygemophorinae, the gnathosoma is carried at least slightly downward and is often bent directly ventrad or posteroventrad. In these forms the propodosomal dorsum is elongated to cover the gnathosomal base, thus displacing the foramen ventrad. The ventral margin of the foramen may be entire or deeply emarginate to allow for the reception of the gnathosoma in those species in which it is normally carried posteroventrally. In *Pygmephorus* and in some *Parapygmephorus* the lateral margins of the circumgnathosomal foramen may be heavily sclerotized, appearing to form a "collar" for the gnathosoma. In such cases the later is carried nearly vertically with only its dorsum and apex exposed. Whether entire or emarginate, the ventral margins of the circumgnathosomal foramen are always greatly thickened to form *apodemes I* (Epimerites I of Krczal) which function to provide strengthening for the anteroventral sternocoxal condyles of coxae I as well as to provide reinforcement for the foraminal margin and points of gnathosomal articulation.

The entire ventral surface of the propodosoma (fig. 3) is the *anterior ventral plate.* It is bounded anteriorly by apodemes I and its posterior limits may (Pygmephorinae) or may not (most Pyemotinae) be well defined by the *posterior marginal apodemes* (Epimera II of Krczal) which are usually most distinct laterally. At the sides, the posterior marginal apodemes bend first dorsally, then anteriorly to provide dorsal support for legs I. In some species of *Myrmecodispus* and *Acinogaster,* these dorsal arms may become enlarged and scapuloid.

Directed longitudinally and joining apodemes I with the posterior marginal apodemes is the *anterior median apodeme* (Sternum I of Krczal). This apodeme may be weak, interrupted, or intermittent (various species), but it is invariably present.

Apodemes II (Epimera I of Krczal) arise laterally near the anterior sternocoxal condyles of legs II and terminate mesally in or near the anterior median apodeme. In the Pyemotinae, Acaro-

phenacinae, and Pygmephorini they are usually straight or sigmoid and join anterior sternocoxal condyles II laterally. A lateral fold or apodeme, which is continuous with apodeme II, is usually present between the anterior sternocoxal condyle of coxa II and the posterior portion of coxa I. In the Microdispini and Neopygmephorini apodemes II are usually distinctly arcuate. In these tribes, they often terminate mesal to sternocoxal condyles II and integumental folds or thickenings continuous with them often reach the areoli of external ventrals I. Apodemes II are weak or absent in *Dolichocybe,* some Microdispini, and some *Parapygmephorus.*

In a few Microdispini, most Neopygmephorini, and most Scutacaridae, a *secondary transverse apodeme* may be present. This apodeme is straight or slightly procurved. It passes near or through the intersection of apodemes II with the anterior median apodeme at about a right angle to the latter. The intersection of these two sutures at the anterior median apodeme delimits between them, on each side, a lateral trianguloid sclerite which bears ventral setae II. In forms possessing this sclerite, external and internal ventrals II are always close together. This arrangement differs from that found in more primitive forms in which the setae tend to be more evenly spaced across the ventrite.

The nomenclature of basal acarine leg segments has long been a subject of disagreement among various workers. Vitzthum (1943) believed the femur and genu (or, in females of Tarsonemidae, genu and tibia) to be fused, the definitive leg segments then being coxa, trochanter, femur (or femurogenu), tibia (or genuotibia), and tarsus. Oudemans thought that the coxae had fused with the sternum, the first definitive segment therefore being the trochanter. Beer (1954) deemed the evidence insufficient to support the view of Oudemans and designated the first definitive segment as the coxa. Krczal (1959) follows Oudemans in believing that the coxae have become flattened and platelike, fusing with the primitive sternum to become the definitive ventral plate. This belief is based largely if not entirely on the fact that the ventral apodemes are of such disposition that they may be construed as being lines of fusion between coxal plates. Other points considered in favor of this thesis are (1) musculature and (2) that in certain prostigmate groups the coxa is generally regarded as being fused with the sternum (*e. g.,* Trombiculidae, *vide* Wharton and Fuller, 1952, Hydrachnellae, *vide* Mitchell, 1955, and others).

The present author does not deny the possibility of correctness of the foregoing hypothesis but wishes to point out the following: (1) The ventral apodemes undoubtedly do not represent the true lines of fusion between the coxae, as a comparative study of the various genera will show, but vary greatly in shape and extent, at least in part according to the requirements for reinforcement and areas for muscle attachment in a particular form, this in turn dependent upon the amount and type of locomotion, carriage of the legs, size and shape of the mite (compare apodemes IV of *Periperipes* and various scutacarids), and other factors. For example, apodemes IV in *Siteroptes*, the species of which have functional hind legs, terminate laterally at anterior sternocoxal condyle IV, a point at which strengthening is needed. In the Neopygmephorini and Microdispini, groups in which legs IV are modified and therefore used sparingly if at all in normal locomotion, the same apodeme terminates in coxal foramen III, usually in its anterior half. Moreover, ventral apodemes are the most poorly developed in what seem to be the most primitive genera (*Dolichocybe, Pyemotes, Trochometridium, Siteroptes*) and in the known larvae, although larvae of all genera studied retain such primitive characters as two claws on tarsus I and five-segmented front legs. (2) Although the coxae of certain prostigmate mites appear to be fused with the venter, no evidence of the relationships of these forms to the Tarsonemoidea has been presented. Indeed, specific examples of such forms are not cited by Krczal in his work. (3) It seems to this author premature at this time to make claims based upon myology since no detailed studies have been made for any group in the Tarsonemoidea. Although it is true that most muscles responsible for leg movement do arise from the ventral apodemes, this does not indisputably establish coxal origins of the latter. Specimens of *Trochometridium tribulatum* cleared in xylene and mounted in balsam by this author resembled certain unionicolids investigated by Mitchell (1955), in that the origins of the muscles inserted upon the first definitive leg segment were diverse. Thus, muscles appearing to be promotors and levators of legs I and II of *Trochometridium* originated side by side from the posterior marginal apodeme and muscles appearing to function as remotors and levators of the same legs originated side by side from the anterior median apodeme well cephalad of apodemes II.

In consideration of the above, it is felt that the assumption of a coxal origin of the ventral plates is based upon meager evidence and

should not be accepted uncritically. In any event, the terms (sternum, epimeron, epimerite) proposed for ventral plates and sutures by earlier authors are morphologically incorrect and there seems to be little reason for retaining them other than historical precedent. This author therefore prefers to use, with modification, the nomenclature used by Beer (Table I).

The four sclerites of the anterior ventral plate called coxae by Oudemans and his followers are accordingly designated as *ventrites,* those anterior to apodemes II as *ventrites I,* those posterior as *ventrites II.*

The anterior ventral plate bears from two to six pairs of setae (fig. 3). If two, four, or six pairs are present, they are equally divided between ventrites I and II. If three or five pairs are present, either ventrite may possess the odd pair. All members of the Acarophenacinae bear fewer than four pairs. Members of the genus *Pyemotes* and all members of the tribes Microdispini and Neopygmephorini bear four pairs, and the remaining genera bear five or six pairs. These setae are named in the manner designated by Krczal (1959b), except that the author prefers to substitute, for reasons explained above, the word "ventral" for "coxal" (Table I). Which of the ventral setae drop out or are added in the various genera is not known and the author arbitrarily designates the pair normally present in some Pyemotinae and Pygmephorini but lacking in the Microdispini and Neopygmephorini as the median ventral pair. External ventrals I are furcate in some species of *Siteroptes, Pseudopygmephorus, Neopygmephorus,* and *Parapygmephorus,* simple in the remaining forms.

The propodosomal dorsum is irregularly trapezoidal, elongate, or inversely T-shaped. Its posterior margin may meet or overlap the first hysterosomal tergum (Acarophenacinae, most Pyemotinae) or be overlapped by the latter (Pygmephorinae). In most members of the last-named subfamily it is delimited posteriorly by a *dorsal transverse apodeme* the ends of which fuse with the dorsal margins of coxal foramina II.

The two variously-shaped *peritremes* (fig. 4) enclose and are usually distinct from the *stigmatal openings.* Both are lacking or at least not discernible in *Pavania* and *Dolichocybe,* but present in all other genera. The shape, proximity, and position of the peritremes are useful in classification at both the generic and specific levels.

Posterior to the peritremes arise the *pseudostigmata.* These two capitate, bladderlike organs are of uncertain function but are almost certainly sensory receptors. Each originates deep within the propodosoma from the *internal pseudostigmatal socket* and usually (exceptions, *Pavania* and *Dolichocybe*) passes through the center of a series of concentric ringed structures, the *external pseudostigmatal socket,* in the region of the body wall. The structure of the rings of the external socket indicates that it is probably capable of response to the slightest movement of the pseudostigmata.

From one to three pairs of dorsal propodosomal setae are present (fig. 4), these often greatly reduced in forms in which the propodosoma is covered by the first hysterosomal tergum. The most anterior pair of these setae ("verticals" of Krczal) are nearly always closely associated with the peritremes and are called the *stigmatals* herein. The most posterior pair ("external scapulars" of Krczal), usually arising mesad or posteromesad of the pseudostigmata and always distinctly longer than the others, is called the *posterior pseudostigmatals.* The remaining pair usually arises anterior or anteromesal to the pseudostigmata and is designated the *anterior pseudostigmatal* pair ("internal scapulars" of Krczal). A predictable sequence of loss usually occurs among these setae, the stigmatals nearly always being lost first, followed by the anterior pseudostigmatals. The number of pairs of dorsal propodosomals is of value in the higher classification of the family while their size and placement is useful in species determination.

In the genera *Acarophenax, Paracarophenax,* and *Adactylidium* a unique division of the propodosomal dorsum occurs. In these genera, the superficial dorsal surface is enlarged to form the *dorsal propodosomal plate* (figs. 46 and 49), its anterior margin covering the gnathosomal region, its posterior margin covering the first hysterosomal tergum. Because of its size and structure, this dorsal plate greatly resembles the enlarged first hysterosomal tergum ("clypeus" of authors) found in the Scutacaridae and in some specialized pyemotids and may easily be confused with it. This parallelism may have led Vitzthum (1943), Hughes (1948), and others to incorrectly assign *Acarophenax* to the Scutacaridae. A smaller, more internal portion of the propodosoma, the *propodosomal arcula,* which is boxlike or nearly so, apparently functions to enclose and, at least in *Acarophenax* and *Adactylidium,* seems to fuse with the reduced gnathosoma, providing areas for muscle at-

tachments and points of articulation. In addition, it bears the peritremes. At least in *Acarophenax* and *Adactylidium* this arcula may be partly or largely sclerotized. In these genera it is visible from above as a heavy U-shaped or tridentoid apodeme, the lateral arms of which bear the anteriorly-directed peritremes at their apices (fig. 5). Other dorsal apodemes may arise from the vicinity of the stigmatal openings, proceeding mesally apparently to fuse with the walls of the buccal cavity. The ventral or anteroventral portion of the arcula, which encloses the more or less reduced mouthparts, may be an anterior extension of the anterior ventral plate, in which case the most posterior setae of the gnathosomal region may be the first internal ventrals. In all three of the above genera the arcula appears to enclose the anterior portion of the gnathosomal region, but this point is not clear.

The bipartition of the propodosoma apparently allows the dorsal plate to separate from the remaining gnathosomal-propodosomal complex, thus allowing more space for the developing young. Rack (1959) illustrates this condition (pp. 416-417) in *Paracarophenax dermestidarum* but does not mention it in the text.

Pseudostigmata are lacking in *Paracarophenax, Acarophenax,* and *Adactylidium.* The dorsal plate bears two or three pairs of setae, while the arcula bears zero to one pair of dorsal or anterior setae and one to two pairs of ventrals. Homologies of the propodosomal setae in these genera are not clear.

Internal anatomy. Structures associated with two major systems, the respiratory and digestive, are usually visible in the region of the propodosoma and may be useful as taxonomic characters.

The peritremes enclose the stigmatal openings, which are usually circular (most Neopygmephorini) but may be slitlike (*Trochometridium*). In some genera (*e. g., Microdispus*) the stigmata open anteriorly, their openings being therefore hidden, but in most cases they turn dorsally into the peritremes and their tubular nature is readily observable. These openings are the terminations of the main tracheal trunks which proceed posteromesally into the propodosoma, each connecting there with a bulbose internal atrium designated by Krczal (1959b) as division III of the tracheal trunk. This division is strongly sclerotized in some Acarophenacinae, a fact which led Hughes (1948) and others to characterize *Acarophenax* as possessing two pairs of stigmatal openings. The posterior end of this division appears sievelike, its external surface giving rise to

TABLE I.—Terminologies of Beer (1954), Krczal (1959) and Cross for Structures of the Propodosoma

Beer, 1954	Krczal, 1959	Cross
.....	.....	circumgnathosomal foramen
apodeme I	epimerite I	apodeme I
transverse apodeme	epimeron II	posterior marginal apodeme
anterior median apodeme	sternum I	anterior median apodeme
.....	anterior sternal plate	anterior ventral plate
apodeme I	epimeron I	apodeme II
.....	.....	secondary transverse apodeme
.....	coxae I–II	ventrites I–II
.....	setae coxales externae, mediae, internae } I & II	external, median, internal } ventrals I & II
.....	.....	dorsal transverse apodeme
stigmatal openings	stigmata	peritremes
stigmatal openings	stigmata	stigmatal openings
.....	.....	internal pseudostigmatal socket
.....	.....	external pseudostigmatal socket
.....	setae verticales	stigmatal setae
.....	setae scapulares internae	anterior pseudostigmatal setae
.....	setae scapulares externae	posterior pseudostigmatal setae
.....	.....	dorsal propodosomal plate (some Acarophenacinae)
.....	.....	propodosomal arcula (some Acarophenacinae)

a number of fine tracheae. These tracheae may be long or short, probably depending (at least to some extent) upon the species. In *Pyemotes* they may reach the posterior extremity of the opisthosoma (Krczal, 1959b), in S. (*Siteroptoides*) they are visible as far as the posterior margin of coxa IV, and in most Acarophenacinae they appear still shorter.

Air was seen to issue only from the structures designated herein as peritremes when specimens of *Pygmephorus* and *Neopygmephorus* were drowned in alcohol and probably these comprise the only external respiratory openings.

The esophagus is often visible within the propodosoma. In some *Siteroptes,* and most Pygmephorinae, one to three separate circumesophageal "finned structures" are distinct within the propodosoma and the anterior portion of the hysterosoma. The anatomy and function of these structures is uncertain at present but Krczal's conjecture that they are esophageal pumps seems reasonable. The shape and number of these structures and the structure of the fins are sometimes used as diagnostic characters (see generic descriptions).

Hysterosoma

The largest and most posterior of the three body regions is the hysterosoma. In dorsal aspect, this region usually consists of four distinct, telescoping body segments, the most posterior usually completely overlapping a fifth [3] segment which may be cuplike or reduced to a ventral plate, or vestigial. Ventrally, the large *posterior ventral plate* bears the third and fourth pairs of legs. Its posterior margin overlaps the platelike *opisthosomal venter* which, in turn, usually overlaps the ventral portion of the fifth segment.

The hysterosoma is movable against the propodosoma, a distinct conjunctiva separating the two. This conjunctiva may arise from the adjacent margins of the two regions or, in those genera in which the first hysterosomal tergum overlaps the propodosoma, the dorsal conjunctiva of the former sclerite may arise from an arcuate transverse apodeme behind its anterior margin. In genera in which physogastry involving the entire hysterosoma is pronounced, the conjunctiva between propodosoma and hysterosoma may be visible as distinct pleated bands which unfold as physogastry progresses.

3. Although Krczal states that the hysterosoma consists of only three dorsal segments and a "*Chitinkappe,*" the present author finds (at least in *Perperipes, Neopygmephorus,* and *Pygmephorus*) four distinct dorsal segments plus the sclerite designated herein as segment V. The latter may or may not be caplike. He is of the opinion that five segments probably also exist in most remaining genera, although in the more specialized forms of the Acarophenacinae the fifth segment may be absent or reduced to a ventral plate which no longer bears setae. Oudemans (1931) mentions species of pyemotids with seven dorsal segments but these observations are probably incorrect.

Dorsum. Sclerites. The first tergum may meet, be overlapped by, (Pyemotinae, Acarophenacinae) or overlap (Pygmephorinae) the posterior margin of the propodosoma. The degree to which the last-named condition occurs varies considerably within the Pygmephorinae. In some forms, only the posterior margin is covered, while in others the entire propodosomal dorsum is hidden. This latter condition has arisen several times within the Pygmephorinae (Microdispini, some *Petalomium, Allopygmephorus*) as well as being characteristic of the entire family Scutacaridae. In the latter family the first tergum ("clypeus" of Berlese and others) is especially large, being expanded both laterally and anteriorly to completely cover the propodosoma as well as the basal portions of the gnathosoma and legs I and II. In the Scutacaridae the "clypeal" margins are always free and radially striate (the striae seemingly conjunctival in origin), a condition only recently discovered in two new genera (*Perperipes* and *Glyphidomastax*) of Pyemotidae. In all other pyemotid genera, if the first tergum is enlarged, its anterior and lateral margins are neither free nor striate.

Tergum I of *Trochometridium* differs from that of all other genera in that it is not entire, but tripartite, consisting of a single quadrate mesal plate and a pair of lateral plates which overlap the former mesally.

Terga II to *IV* are bandlike and, except for their posterior margins, which may be procurved in some species (*e. g., Pseudopygmephorus sellnicki*), and for their setation (which will be discussed later), offer no unusual modification. In a few forms, a pair of rounded, pale areas are visible on segments II or III. These mark the dorsal insertions of the dorsoventral muscles. In some species, a wide band of conjunctival pleats is visible between terga III and IV.

Segment V is usually completely overlapped dorsally and laterally by segment IV. In lateral mounts and in dissected specimens it is often seen to be a cuplike cap which encloses the posterior end of the mite. It bears the slitlike apical or apicoventral vulva. In *Dolichocybe* and *Pavania* the fourth segment forms the terminal cap. In these two genera its anterior margin is contiguous ventrally with segment V, the latter plate-like and bearing a single pair of short setae which flank the vulva. The anterior margin of segment V is contiguous in turn with a separate, flattened sclerite, the *antevulvar plate* (fig. 17), unique to these two genera. The latter bears an internal genital sclerite and, externally, two pairs of tiny setae. Its origin is unknown. In *Pyemotes* and in the more specialized Acarophenacinae, a reduction of the fifth segment is also

found, this accompanied by a reduction or loss of the setae therefrom.

Setation of dorsum. The setation of the hysterosomal dorsum is generally consistent and perhaps homologous throughout the Tarsonemoidea and is quite similar to that found in many families of the Prostigmata. Without exception, the first hysterosomal tergum bears two pairs of setae, the second a single pair (fig. 4). The third tergum bears two pairs of setae in all forms except several species of *Siteroptes,* in which only a single pair may be present. Tergum four bears two pairs of setae except in *Metasiteroptes macer.* Setation of the fifth segment is variable. One pair is present in *Dolichocybe, Pavania,* and *Pyemotes,* all remaining pyemotine genera possessing three pairs. Acarophenacine genera resemble *Pyemotes* in having one pair except for *Adactylidium* and some *Acarophenax,* in which segment V is without setae. Three pairs of setae are present in all Pygmephorini, in a few Microdispini, and in most (exception, *Allopygmephorus*) Neopygmephorini. In most Microdispini and in *Allopygmephorus* only two pairs are present. The number, shape, and position of the dorsal setae are used to separate both species and genera. The author believes the setae of the first four terga to be homologous, and in order to show this homology, as well as for purposes of simplification, further modifies Krczal's modification of Paoli's (1911) terminology (Table 11).

Venter. Sclerites. Ventrally (except in *Pavania* and *Dolichocybe*) the hysterosoma consists of but two easily recognizable plates, the *posterior ventral plate* and the large *opisthosomal venter* (fig. 3). The former bears the two posterior pairs of legs. If it is primitively composed of the sterna of two segments (and in addition, perhaps, the fused coxae), then no line of fusion between these segments exists in the genera presently known. In two forms, *Siteroptes* (*Metasiteroptes*) and *Pediculaster* (*Acarothorectes*), a transverse division of the posterior ventral plate occurs, but this is undoubtedly a secondary development. In the genera *Pyemotes* (fig. 21) and *Trochometridium* (fig. 30) this plate is tripartite, consisting of two lateral portions and a mesal portion. The former meet and overlap only in the anterior portion of the plate. Dorsal to these two lateral plates and between their mesal margins is the triangular mesal portion of the plate, easily recognizable by its shape and position and because it bears a single pair of poststernal setae. In all remaining genera the posterior ventral plate is entire.

The anterior margin of the posterior ventral plate is entire and recurved. Laterally, each margin consists of a single flap which extends dorsally to cover the lateral margin of the second hysterosomal tergum, but lies beneath that of the first tergum. At least in *Acarophenax tribolii* each lateral flap is split (fig. 43) along a line terminating ventrally near the anterior margin of coxa II. The posterior portion of this flap covers the lateral portion of the second tergum as described above, while the anterior portion is enclosed by the first tergum. In all other genera the lateral flaps are seemingly entire.

In those forms in which the posterior ventral plate is entire, its posterior margin may be variously excavated, linear, or lobate. In *Dolichocybe, Paracarophenax,* some *Pseudopygmephorus,* and in most of the Microdispini, this margin is tripartite.

The posterior ventral plate has four apodemes whose development and shape are useful in classification. The *posterior median apodeme* may be present in varying degrees or absent. It corresponds to and often appears to be a continuation of the anterior median apodeme. *Apodemes III* and *IV* are diagonal or transverse and may be complete or incomplete in the various genera. In presumably primitive Pyemotinae (*e. g., Dolichocybe, Pavania, Pyemotes*), and in some Acarophenacinae, these apodemes are well developed only laterally and serve to strengthen the anterior sternocoxal condyles of their respective legs (figs. 13, 21, 43, 45, 48). The posterior median apodeme is usually completely absent in these forms. Assuming the above arrangement to correspond to the primitive condition, figure 7 illustrates a proposed sequence of stages in the evolution of these apodemes. In general, there is a tendency toward the increased development of apodemes III and IV as well as the posterior median apodeme in the higher Pyemotinae and lower Pygmephorinae [some *Siteroptes s. s., S. (Siteroptoides), Pediculaster*], followed by a decrease in size and distinctness in the higher Pygmephorinae. There is, however, a continuous trend toward the anterior migration of apodemes III and IV in all genera, culminating in the arrangement depicted in *Neopygmephorus* (fig. 7h). In this genus, apodemes III are entirely or almost entirely lost and apodemes IV have lost their original contact with the anterior sternocoxal condyles of legs IV, their lateral terminations joining the anterior halves of the inner margins of coxae III instead. *Apodemes V* are present only in *Trochometridium* and some species

of the genera *Siteroptes, Pediculaster,* and *Pygmephorus.* They extend obliquely from coxal foramina IV to the posterior termination of the posterior median apodeme. Probably the loss of the strengthening apodemes of legs IV and their migration anteriorly is correlated with changes with the modification of legs III and IV (p. 64).

In all genera but *Dolichocybe* and *Pavania, t*he opisthosomal venter is a single, large plate whose anterior margin arises beneath the posterior margin of the posterior ventral plate and whose posterior margin overlaps the ventral portion of the fifth segment. The shape of the margin of the latter varies intraspecifically in at least some forms. The lateral margins of the opisthosomal venter resemble those of the posterior ventral plate in being flaplike. They probably cover the lateral margins of the third tergum and lie beneath the second tergum in the manner shown by Krczal (1959b, p. 388) although this cannot be verified in all genera. A band of pleated conjunctiva may connect the posterior ventral plate with the opisthosomal venter. In *Pyemotes* and in some Acarophenacinae a second band may be present between the opisthosomal venter and segment V. In *Dolichocybe* and *Pavania* (figs. 13, 17), the opisthosomal venter is divided into a pair of earlike lateral lobes. These lobes do not meet medially and are separated posteriorly from the antevulvar plate by a distinct, pleated conjunctival band. Their lateral margins were not seen by this author.

Setation of the venter. The setal nomenclature of the posterior ventral plate proposed by Paoli and retained by Krczal (1959b) is utilized here without change (Table II and fig. 3). Six pairs of setae occur on this plate in all forms except the following, in which this number is reduced: all of the Acarophenacinae except *Caraboacarus, Pyemotes,* certain species of *Siteroptes,* and certain species of *Pediculaster.* In the first group mentioned, one to three pairs may be lacking, while the remaining genera lack one or (rarely) two pairs.

The *internal presternals* are always present, arising near or in front of apodemes III (or their remnants) usually near the posterior median apodeme. The *first axillaries* arise near to well anterior of apodemes III and near the margin of the third coxa. They are invariably present. The *external presternals* always arise at least slightly behind the internal presternals and distinctly mesal to the first axillaries. In most Pygmephorinae these setae arise near or anterior to apodemes IV. They are rarely absent (some Acarophenacinae). The *second axillaries* arise anteromesal to but near

TABLE II.—Comparative Terminology of Beer (1954), Krczal (1959), and Cross for External Structures of the Hysterosoma

Beer, 1954	Krczal, 1959	Cross
.....	tergites I–III	terga I–III
.....	chitinkappe	tergum IV
.....	chitinkappe	segment V
.....	ventral shield I	posterior ventral plate
.....	ventral shield II	opisthosomal venter
apodeme III	epimerite III	apodeme III
apodeme IV	epimeron III	apodeme IV
.....	epimeron IV	apodeme V
posterior median apodeme	sternum II	posterior median apodeme
.....	axillares I	axillaries I
.....	axillares II	axillaries II
.....	setae praesternales externae and internae	internal and external presternals
.....	setae poststernales externae and internae	internal and external poststernals
.....	.....	opisthosomal ventrals
.....	humerales internae	dorsals I
.....	humerales externae	laterals I
.....	dorsales	dorsals II
.....	lumbales internae	dorsals III
.....	lumbales externae	laterals III
.....	sacrales internae	dorsals IV
.....	sacrales externae	laterals IV
.....	caudales internae	internal caudals
.....	caudales externae I	external caudals I
.....	caudales externae II	external caudals II

coxa IV (or from near the lateral terminations of apodemes IV in some Pyemotinae). They may migrate anteriorly as far as the center of the third coxal foramen (some Microdispini). They are invariably present. The *internal poststernals* arise in line with or behind the second axillaries and close to the posterior median apodeme. They may be absent in some Pyemotinae and Pygmephorinae. The *external poststernals* arise near or (usually) posterior to a line drawn between the anteromesal margins of coxal foramina IV, and are distinctly lateral to the internal poststernals in all known species. They may be absent in some species.

Internal morphology. The sclerotized portions of two systems, the digestive and reproductive, may be recognized in the hysterosomal region of cleared specimens of pyemotid mites. In unfed mites the former may be seen only rarely posterior to the dilated esophageal pumps. In such cases, it appears as a straight tube, similar to the esophagus in diameter, which seemingly ends blindly in the region of the third tergum. Several authors have thought the anus to be present but it has been established, at least in *Pyemotes* (*vide* Brucker, 1901, and Pätau, 1936) and *Siteroptes* (*vide* Reuter, 1909a), that the gut ends blindly. Reuter states that the anus is lost completely in *Siteroptes* except for a transitory "*Exkretionsporus*" found in the early embryo.

The structure of the reproductive system is much more complex. Brucker (1901) and Reuter (1909a) have investigated this system in *Pyemotes* and *Siteroptes* respectively and report similar findings which may be summarized as follows: The female genital organs are simple and consist of the *vulva*, which serves both as the true vulva and the ovipore or birth opening. This opens into the tubular *vagina* (oviduct of Reuter), from which a pouchlike dilation (the *receptaculum seminis*) may arise. The vagina opens anteriorly into the single bulbose *ovary*. In both of the above species the female becomes greatly swollen when gravid. Information presented below indicates that, at least in the more specialized pyemotids, the above anatomical details are probably oversimplified and that a separate oviporus is present in at least some forms.

Certain sclerites or genital thickenings found in cleared specimens have been largely ignored by earlier authors. The functions of these structures are not presently known but their presence and shape are useful in classification. In the Pyemotinae (except for some *Siteroptoides*) and Acarophenacinae, such sclerites are usually indistinct, except that rodlike, globular, or omega-shaped structures

are often found in *Pyemotes, Trochometridium,* and *Siteroptes.* These latter structures have been thought to be spermatophores (Pätau, 1936) or spermathecae. Species of *Siteroptes* and *Trochometridium* possess, in addition, a subapical, circumvaginal sclerite which may be subglobose to elliptical in shape.

Members of the Pygmephorini possess a variety of distinct sclerites in addition to this vaginal sclerite. In the Microdispini and Neopygmephorini, and in some Pygmephorini, one or more of three genital sclerites may be present; these are probably homologous between species. For the sake of convenience, they are designated simply as the anterior, median, and posterior sclerites. These sclerites vary somewhat in shape and distinctness between species and even between specimens of the same species (due to mounting) yet are usually recognizable and useful in classification.

The *anterior genital sclerite* is usually long-triangulate, sometimes appearing to be folded flaplike, its apex directed anteriorly. It arises near a line drawn between the posteromesal margins of coxal foramina IV except in *Pygmephorus* and some *Pediculaster* in which it arises well behind this line.

The *posterior genital sclerite* is situated well behind the anterior genital sclerite and anterior to any apical vaginal sclerotization or structure. It is usually well defined and elongate straplike, or triangular. If triangular, it is also folded, flaplike, and seemingly arises from the anteroventral margin of the cuplike fifth segment. In the more primitive Pygmephorini this sclerite is usually not separable from several accompanying ones and may be absent entirely.

The *median genital sclerite* (fig. 91) is a round, triangular, or irregularly shaped structure situated between the two preceding sclerites. It is present only in *Acinogaster* and in some *Parapygmephorus.*

Structural modifications associated with physogastry. Physogastry, the monstrous enlargement of the body of gravid female mites, has been previously thought to occur throughout the family Pyemotidae to about the degree well known in the genus *Pyemotes.* Although much work remains to be done on this problem, seemingly the extent of such physogastry varies greatly among the genera of the family. Moreover, the areas of the body entering into physogastry differ quite markedly in different genera.

Genera known to swell to several hundred times their original volume include all of the genera of the Pyemotinae and of the

Acarophenacinae except *Caraboacarus* and *Adactylidium* (about which information is not available), and at least some species of *Pediculaster* and *Perperipes*. The latter genus is of particular concern here and will be mentioned later.

Females of *Pygmephorus* are known to swell considerably but seemingly to a lesser extent than the genera mentioned above. The same is probably true for *Microdispodides* and some *Parapygmephorus*, although specific information concerning them is not available. As regards the Microdispini, all gravid specimens of *Microdispus* and *Peponocara* studied by this author contained only one or two large eggs and showed only a slight increase in body size. This situation is nearly identical to that occurring in the genus *Imparipes* of the family Scutacaridae. On the other hand, *Perperipes*, which is considered to be one of the most specialized forms within the Microdispini, becomes enormously physogastric. However, its physogastry is believed to differ considerably from that found in the Pyemotinae (see below).

In the groups exhibiting pronounced physogastry, three main types of this condition, based upon the location and extent of the areas involved, may be recognized.

(1) Opisthosomal physogastry. In this type the metapodosoma enters only slightly into the swelling and pleated conjunctival bands between the propodosoma and hysterosoma are absent or weakly developed. Swelling therefore occurs only in the opisthosoma, this region becoming enormously distended and spherical. As far as known, physogastry of this kind occurs only in the genus *Pyemotes*.

(2) Hysterosomal physogastry. This is the most common type found within the family, the entire hysterosoma becoming swollen and spherical. A distinct band of pleated conjunctiva is usually present between the propodosoma and hysterosoma. This type of physogastry is known to occur in *Dolichocybe, Siteroptes, Trochometridium, Resinacarus, Pediculaster*, and, to a lesser extent, in *Pygmephorus*.

(3) Idiosomal physogastry. This type is restricted to the more specialized members of the Acarophenacinae (*Acarophenax, Paracarophenax*, and probably *Adactylidium*) in which the propodosoma is bipartite in the manner described previously (p. 49) and therefore enters into the swelling. The entire body, except for the greatly reduced gnathosomal portion (including the arcula of the propodosoma) is therefore affected.

In the physogastric females thus far examined, it is obvious that most of the gross enlargement of the body which accompanies the development of the ova takes place in the intersegmental conjunctiva, since measurements of the sclerites indicates that these do not change appreciably in size. What proportion of this conjunctival enlargement is due, however, to the unfolding of the conjunctival pleats and what proportion to conjunctival elasticity is not known. Richards (1951) pointed out that cuticle varies considerably in this regard, elasticity being correlated with the degree of orientation of the micelles, and it is possible (as in Ixodides) that considerably more elasticity occurs in the cuticle than has been heretofore supposed.

Physogastry in Perperipes. The physogastric females (figs. 8, 9) of this genus differ greatly from those of all other pyemotids, and apparently are mimics of the doryline ant larvae among which they live. In these females the pleats of the intersegmental membrane vary in diameter in such a manner that, posterior to the second tergum, they form a regular series of 7 to 9 annuli when extended, these superficially resembling the segments of a larval ant. The fact that these "pseudosegments" may possess spicules like those of maggots leads one to suspect that this mimicry may be further extended to include locomotory or other behavioral characteristics.

During physogastry the female becomes increasingly elongate, although body width remains approximately the same as in the non-gravid form. This elongation takes place only in the following regions: between dorsal segments II and III, between III and IV, and between IV and V. Only a slight separation occurs dorsally between the propodosoma and hysterosoma. Dorsal segments I and II bear the same relationship to each other as in the non-gravid female.

Ventrally, the female is unmodified as far posteriorly as the hysterosomal venter, the latter remaining in its original position at all times. From beneath this sclerite, however, and apparently attached to the hind margin of the posterior ventral plate, there arises a greatly elongate conjunctival area which extends to the posterior end of the venter, where it joins the fifth segment. This area is easily visible in cleared specimens of non-gravid females as a thick band of conjunctival pleats. In physogastric specimens, its anterior portion, located directly behind legs IV and beneath the hysterosomal sternum, is distinctly convex and has a longitudinal

slit, the *oviporus*, along nearly its entire length. This convex portion, herein designated as the *oviporal plate* (fig. 8), is darker and more brittle than the more posterior portion of the ventral conjunctiva and is separated from it by an apodemelike ring which is not distinct in all specimens. This ring occurs ventrally in the region of the posterior genital sclerite and joins the posterior margin of the second hysterosomal tergum dorsally, thus, in effect, dividing the entire mite into two areas.

The anterior of these areas is bulbose and slightly larger in girth than the posterior and, because it is composed nearly entirely of sclerotized plates, appears somewhat darker than the latter. It superficially resembles the head of a larval coleopteran or nematocerous fly. The posterior portion is composed almost entirely of conjunctiva except for the widely separated terga III to V. As mentioned above, this conjunctiva is constricted at regular intervals at and between the true segments, giving the female a segmented appearance. Numbers of these "pseudosegments" appearing between the true segments are as follows: two or three between segments II and III; three between III and IV; one or two between IV and V. Segment V is always situated apicoventrally or ventrally.

The origin of the oviporus is unclear. Its anterior termination is seemingly marked by the anterior genital sclerite, its posterior termination by the posterior genital sclerite. It is not visible in non-gravid females. It is probably either a modification brought about by and unique to the gravid state or, as seems more likely, is always present in the pleated conjunctiva of non-gravid forms, becoming definitive during the unfolding of the latter. Its length is such that it would extend beyond the hind margin of the body in non-gravid forms. Its elongation is brought about by the posterior migration of the posterior genital sclerite, the anterior sclerite remaining in the same position as in the non-gravid form.

Musculature in Perperipes. Two sets of longitudinal muscles are seen to pass through the first tergum to connect the posterior dorsum of the propodosoma with tergum II. Terga II, III, and IV are connected to each other by two similar sets of muscles, these capable of elongation to permit the expansion of the body in these areas. A single pair of muscles connects the fourth tergum with segment V. All longitudinal muscles arise anterior to the setal bases.

In addition to the longitudinals, dorsoventral muscles are present as follows: (1) three pairs between the first tergum and the venter, the anterior pair originating upon the posteroventral margin of the

anterior ventral plate, the mesal pair upon the lateral prolongation of apodemes III, and the posterior pair upon the posterior ventral plate anterior to coxae III; (2) one pair between the second tergum and coxae III; and (3) one elongate pair between the third tergum and the oviporal plate, immediately behind the posterior genital sclerite. No dorsoventral muscles were seen between tergum IV and the opisthosomal venter or segment V.

If these muscles are indicative of the primitive relationships between the terga and sterna of true segments, it is clear that at least the ventral division between propodosoma and hysterosoma is of a secondary nature. As regards the relationship between the third tergum and the oviporal plate, it is possible that this plate represents the invaginated third sternum, the opisthosomal sternum therefore representing the sternum of the fourth segment.

In view of Mitchell's (1955) findings in the Unionicolidae as well as the observations mentioned earlier (p. 47) concerning the stability of muscle attachments, any speculation based largely or entirely upon these would seem questionable.

Reproductive organs of Perperipes. The most striking feature of this system and one not visible in non-gravid females is the large, muscular *oviduct,* whose external opening is the oviporus. Within this duct fully formed larvae may be seen, these still within the chorion. More or less within the center of the greatly enlarged *uterus* and in direct access to the *oviduct* are the most mature embryos, these decreasing in maturity as one proceeds posteriorly. On each side of the uterus and lateral to the oviduct a germarium is present, the embryos showing a progressive increase in maturity as they move from this region posteriorly to the tip of the hysterosoma. In the most posterior portion of the uterus the embryos from each side merge to form a single stream moving anteriorly into the oviduct.

The true vulva, still visible in segment V, appears to be dissociated from the uterus. It clearly does not function in oviposition.

Legs. The legs of pyemotid mites may be composed of either four or five segments. As explained earlier, this author has chosen to call the most basal free segment the *coxa,* this segment therefore corresponding to that designated as trochanter or trochantofemur by most European workers. The next proximal segment is weakly to strongly subdivided, this being most noticeable on legs III and IV. This segment is called the *trochanter* herein. The remaining segments, *femurogenu, tibia,* and *tarsus,* are named in order begin-

ning with the most basal, their nomenclature corresponding with that in use by most European acarologists. The pretarsus is not considered herein to be a segment. In cases where one segment is lost, the loss is due without exception to the fusion of tibia and tarsus. This fusion occurs in leg I of all Acarophenacinae but *Caraboacarus,* in the genus *Resinacarus,* and in all Pygmephorinae. *Caraboacarus* is unique in having tibia and tarsus IV fused, the line of fusion still visible.

The articulation of the legs (notably that of I and IV) to the body undergoes an interesting evolution within the different genera. In the Pyemotinae and in the less specialized Pygmephorinae (some *Pygmephorus,* some *Pediculaster*) legs I are carried straight forward and their articulations (as seen in ventral aspect) are at approximately a right angle to the longitudinal axis of the body. Within the Acarophenacinae and Pygmephorinae, a parallel transition to an oblique type of articulation occurs, this transition seemingly quite abrupt in the former group. Whether the change in the carriage of this pair of legs is correlated with a corresponding change in their function is not known.

In the more primitive Pyemotinae, *e. g., Dolichocybe, Pavania, Pyemotes, Metasiteroptes,* as well as in most Acarophenacinae, coxae IV are triangular and similar to coxae III in shape and points of articulation, and therefore in movement. In these groups, two ventral condyles, one at the anterior, one at the posterior extremity of the coxa permit the entire leg to be abducted and adducted at approximately a right angle to the longitudinal axis of the body. Flexion-extension is accomplished at the coxo-trochanteral joint. In the higher Pyemotinae and in the entire Pygmephorinae, coxa IV differs from coxa III greatly in shape, number and position of condyles, and in function. In these mites the coxa becomes quadrate (*Siteroptes, Trochometridium*), then rectangulate and greatly flattened (most Pygmephorinae). In the latter, the coxal foramen is nearly slitlike and the base of the coxa becomes increasingly covered by the posterior ventral plate. Concurrently, there is a gradual posterior migration and accompanying enlargement of the anterior sternocoxal condyle until, in the Pygmephorinae, this condyle is found on the inner surface of the posterior ventral plate near the center of the coxal base, where it projects dorsally into a socket on the ventral surface of the latter. In some but not all Pygmephorini the posterior condyle seemingly is vestigial or lost. It appears that in these forms the capability for abduction-adduction

of legs IV has become restricted and may be, in some cases, partially replaced by one for flexion-extension. In this respect, these mites show a close affinity to those of the family Scutacaridae.

Tarsi I to IV vary in the number and development of the claws, these oftentimes being of diagnostic value. Tarsus I bears zero to two, the latter condition being present only in the genera *Pavania* and *Dolichocybe,* the former having arisen independently in a number of genera. The usual number of claws on this leg is one and the pulvillus is lacking except in the form designated herein as *Dolichocybe fusiformis* (Krczal, 1959), and in *Pavania.* Claw I may be sessile or pedicellate in varying degrees. It is usually enclosed basally within a membranous or sclerotized cuplike pretarsus which may be elongate along its inner margin to form an opposable "thumb." The latter may be absent (*Siteroptes,* most *Pseudopygmephorus*) to well developed (most *Pygmephorus*) and may be entire, dentate, or cleft for the reception of the claw. In *Trochometridium,* two thumbs are present, one of which is setalike and perhaps is not of pretarsal origin. This thumb may be capable of movement.

In many forms in which claw I is sessile, its position is twisted or otherwise distorted. The pedicel is always present and usually long and slender in those forms in which the thumb is absent.

Claw I may be tiny and subsetiform (some *Myrmecodispus*) to very large (*Pygmephorus*) and it may be simple and hooklike (*Siteroptes,* some *Pseudopygmephorus*) or bulbose basally (many genera).

A general correlation exists between the size and shape of claws I and the occurrence of phoresy. Notable exceptions occur in *Caraboacarus, Peponocara,* and *Glyphidomastax,* in which the claws are lacking. Phoresy is only rarely known in species in which claws I are long-pedicellate or simple and hooklike.

The ambulacra of legs II and III are invariably identical in shape, both claws and pulvilli being present except in *Acarophenax* and *Adactylidum,* in which the claws are lacking. If present, the claws of these legs are always paired and may be simple, cleft, or toothed. The pulvillus is disclike or flaplike, usually longer than the claws. Tarsus IV resembles tarsus I in having lost the claws independently in several genera (*Caraboacarus, Acarophenax, Adactylidium, Microdispodides, Glyphidomastax, Perperipes*) but differs in retaining the pulvillus after such a loss. Claws IV, if present, are often reduced in size and are only rarely cleft or dentate.

In several genera, a round or irregularly-shaped thickened area may be present on tibiotarsus I. This area is mediolateral in location, usually arising between solenidia 2 and 3, and perhaps is associated with the fusion of the tibia and tarsus. It may appear dorsal, circular, and well separated from the lateral margin of the segment, or marginal and irregular.

Setation. The number and placement of leg setae are useful in classification at both the specific and higher category levels. Krczal (1959b) has mapped and attempted to homologize these setae. The practical benefit derived therefrom is great and the setal nomenclature proposed by Krczal is used in this paper (figs. 10-12). It should be pointed out, however, that considerable shifting of these setae may occur, and in addition certain tactiles may be replaced by sensory setae and *vice versa.* The identification of homologues must therefore be viewed with reservations.

Coxae I to IV always bear one seta except in *Dolichocybe, Pavania,* and in some *Adactylidium,* in which coxal setae are lacking. The setation of the remaining segments differs considerably between legs and is best discussed by reviewing the latter in sequence.

Trochanter I bears four setae in the Pyemotinae except for *Trochometridium* (which has five), in the higher Acarophenacinae, in *Pediculaster,* and in some *Pygmephorus,* all other forms bearing three. The structure of seta *c* (the apicolateral dorsal) of this segment is variable, being setiform in the Pyemotinae, Acarophenacinae, and Microdispini, but stout, elongate, and obtuse or spatulate apically in *Pediculaster,* and short, bladelike, and usually proflexed apically in the remaining genera. This same seta undergoes further modification in the family Scutacaridae (Beer and Cross, 1960). Seta *d* (the apicomesal dorsal) of this segment may be setiform or modified and undulate. Trochanter II usually bears three setae (two in *Dolichocybe*), trochanter III from one to three, and trochanter IV two or, rarely, one.

Femurogenu I bears three or four tactiles except in *Dolichocybe* and *Pavania,* which have only two. Femurogenu II possesses from one to three, femurogenu III from one to three but usually one less than the number found on femurogenu II, and femurogenu IV one or two.

Tibia I, if separate, bears five or six tactiles and two solenidia (nos. 1 and 2 of Krczal, 1958). Tibiae II to IV invariably bear four

tactiles and zero, one, or two solenidia in addition. The usual number of such solenidia is one (Solenidium 1 of the leg concerned) and if two are present (only on tibia II of some *Parapygmephorus*) then one arises from the apical margin of the segment and is undoubtedly the basal tarsal solenidium (Solenidium 2). The single true solenidium (1) of the tibia becomes lost more often from leg III than from leg II and from leg IV more often than from leg III. Genera lacking this solenidium on leg III are *Paracarophenax* and some *Pyemotes*, while the same solenidium is absent from both legs II and III of the genera *Dolichocybe*, *Acarophenax*, and *Adactylidium*.

Tarsus I, if distinct, bears 13 to 15 setae, six to nine of which are tactile. Tarsus II bears from five to eight tactiles and a single solenidium which is invariably present except in some *Parapygmephorus* where it may arise from the tibia (above). Tarsus III bears from four to eight tactiles and always lacks a solenidium. Tarsus IV bears from three (*Adactylidium*) to seven (*Trochometridium*) tactiles, the usual number being six. Solenidia are always absent on tarsus IV.

In the subfamilies Pygmephorinae and Acarophenacinae except for *Caraboacarus*, and in the pyemotine genus *Resinacarus*, tibia and tarsus I are fused. In these genera the total number of setae varies between 17 and 21. The two short, lateral, usually clavate solenidia found on each of the two original segments (solenidia 1 to 4) are easily recognizable and provide landmarks for further setal recognition. In the Pygmephorinae and in the family Scutacaridae, certain sensory setae may be borne upon distinctive cylindrical or irregularly-shaped pedicels termed *pinnacula* herein. The number, shape, and setal complement of these structures may be useful in classification at specific or generic levels.

The setal designations of Krczal probably oversimplify the true setal picture of this compound segment since, in reality, about half the setae, particularly those of the lateral surface, are rodlike sensory setae, many so closely resembling tactiles as to be nearly indistinguishable from them.

It is obvious that use of such terms as "tactiles" is quite arbitrary and merely follows custom; nothing is known of the functions of the various sensilla.

MORPHOLOGY OF THE MALE

General

As in the remaining Tarsonemoidea, a great deal of dimorphism occurs between the sexes. Unlike the remaining families, however, in which this dimorphism is usually uniformly established to a high degree, males of the Pyemotidae show a sequence of modification from which one may speculate upon probable relationships occurring within the superfamily.

This sequence begins with *Dolichocybe* and terminates along one phyletic line with the Neopygmephorini and the Scutacaridae, males of these two being indistinguishable from each other at the present time. A second line of descent, less clear than the preceding, seemingly passes from a *Dolichocybe*-like form to the Acarophenacinae. Mites of this subfamily show many affinities to the Tarsonemidae and the Podapolipodidae but their relationship to these two families is not clear.

Although *Dolichocybe* is considered here to be primitive, even in this form a great deal of morphological disparity occurs between the sexes. In addition to primary sex modifications, this dimorphism involves body shape (the female being elongate and cylindrical, the male much shorter and stouter), gnathosomal shape (more elongate in females), the length of the legs (comparatively longer in the female), the loss of the pseudostigmata in the male (a pair of setae is present which are probably their homolgues, however), and very minor setal differences on the legs. When compared with the extreme modifications of males in other genera, however, the males of this genus are relatively unspecialized.

Because of the lack of material, males being rare in many species, a more detailed study of the comparative morphology of the males of the family is unfortunately not possible at this time. The following is based on information obtained from the study of the males of the following: *Dolichocybe keiferi; Pyemotes* (one species); *Siteroptes, s. str.* (four species); *Trochometridium tribulatum; Neopygmephorus, s. str.* (one species). In addition, males of several unidentified species of Pygmephorinae as well as of the families Scutacaridae and Tarsonemidae were also utilized for comparative studies. The drawings and descriptions of the males of *Acarophenax, Paracarophenax,* and *Resinacarus* (found respectively in Newstead & Duvall 1918, Rack 1959, and Vitzthum 1927) have provided additional information.

As in the females, taxonomic separation of the males of the more primitive genera is seemingly quite simple, that of higher genera less so. Perhaps, in the case of the males, this is illusory because of the few species available for comparison.

Gnathosoma

This region may be functional and developed to varying degrees (*Dolichocybe, Pyemotes, Resinacarus, Acarophenax, Paracarophenax,* all Tarsonemidae and Podapolipodidae) or completely reduced and nonfunctional (*Trochometridium, Siteroptes, Neopygmephorus,* two other unidentified Pygmephorinae, and all known Scutacaridae). In the latter case, this region consists only of one or two lobes bearing several pairs of setae. The oral opening, mouthparts, and palps are completely lacking when the gnathosoma is reduced.

In forms in which the gnathosoma is well developed (*Pyemotes, Dolichocybe*), its setation is similar to that of the female. In the latter genus the gnathosoma is shorter and broader than that of the female and differs otherwise in having the palps fused to the gnathosoma. The pharyngeal pump and esophagus is distinct in males of this genus despite the fact that the chelicerae are not visible.

Propodosoma

This region is always wider in the male than in the female. The dorsum of males differs from all females except those of *Dolichocybe* and *Pavania* in lacking peritremes, and indeed, all traces of stigmata. Males further differ from all females, except those of the specialized Acarophenacinae, in lacking pseudostigmata. In all genera observed except *Trochometridium,* however, an extra (fourth) pair of propodosomal dorsals occur which may well be the homologues of these organs.

The propodosomal venter resembles that of the female in setal number except in the Pygmephorinae. Generally speaking, the apodemes of the anterior ventral plate resemble those of the female. Males of *Neopygmephorus* differ from their females in that their first coxae articulate in the primitive manner, *i. e.,* at a right angle to the longitudinal axis of the body. In all other genera studied the sexes agree in this respect.

The posterior margin of the male propodosoma usually meets, or is separated by a wide zone of conjunctiva (*Trochometridium*) from, the hysterosoma. It neither covers nor is covered by the anterior margin of the first hysterosomal tergum.

Hysterosoma

Like that of the female, the male hysterosoma is capable of undergoing great modification in many, if not most, areas and organs. These modifications generally seem to be adaptively correlated with the use and disuse or modified use of the legs and genitalia.

Only in *Dolichocybe* does the male retain a close resemblance to the female in numbers of segments and setae. In this genus four bandlike dorsal segments are visible, the fourth apparently covering a reduced fifth which may be fused with the opisthosomal venter. The number of dorsal setae resembles that of the female. In all remaining genera a fusion of terga I and II has occurred, the maximum number of dorsal plates therefore being three. In *Paracarophenax* and *Resinacarus* tergum III appears to be terminal, but in the remaining genera this sclerite is subterminal and platelike. It bears one (rarely) or the usual two pairs of setae. The males of *Acarophenax, Paracarophenax, Dolichocybe, Trochometridium,* and *Resinacarus* are broadly rounded or broadly truncate posteriorly. In these forms the opisthosoma is not greatly constricted or otherwise modified into a globular or conical copulatory structure. In the first two genera above, the aedeagus is displaced ventrally and emerges from a *genital plate* which may consist of portions of tergum IV and segment V. In *Dolichocybe* and in *Trochometridium* the genital aperture is ventral and terminal but the latter genus differs from the former in that a terminal concavity exists between segment IV and segment V, the latter bearing the aedeagus.

In *Pyemotes, Siteroptes, Neopygmephorus,* and in at least some Scutacaridae, tergum IV, segment V, the opisthosomal venter, and perhaps some phallic structures associate to form a conelike or subglobular *genital capsule.* Since the gnathosoma in these forms is vestigial and because the aedeagus is prominent and often bipartite, this capsule easily may be mistaken for the gnathosoma. The genital capsule may be relatively small and subtruncate or concave apically (*Pyemotes*) to very large and acuminate (*Neopygmephorus*). Tergum IV forms the dorsal plate of this capsule. This tergum is seemingly modified for the reception of the female opisthosoma during copulation and may be roughened, punctate, concave, or provided with membranous "wings." It usually bears two pairs of basal setae, of which at least one pair is sensory. Apically, tergum IV encloses the fused fifth segment and opisthosomal venter,

these last containing the male genital orifice. At least in *Neopygmephorus*, these last two sclerites may be tripartite, the two lateral lobes formed by such a division being flaplike. It is possible that these flaps may further assist in positioning the female prior to copulation.

The basal portion of the genital capsule is enclosed ventrally by the greatly constricted hind portion of the posterior ventral plate except in *Pyemotes*, in which the ventral portion of the capsule may be free.

Broadly speaking, the arrangement and development of apodemes III and IV found in *Dolichocybe* and *Acarophenax* resemble that of their respective females. In *Paracarophenax* these apodemes are distinctly stronger than in the female. In the remaining genera they are strong, usually complete, and often differ markedly in location and shape from those of their respective females. These changes are probably associated with the modification of legs IV as clasping organs and may reflect corresponding changes in the copulatory position.

In *Dolichocybe, Pyemotes, Acarophenax, Paracarophenax,* and *Trochometridium,* the *penis* is a short, rigid, blunt or hooked organ which is usually divided longitudinally into halves. In *Siteroptes* it is longer, tubular, and acuminate apically but still rigid. The males of *Neopygmephorus* and the scutacarid genus *Imparipes* possess a structure similar to that of *Siteroptes* (fig. 100) but very long and flexible and having taenidia-like thickenings.

The author has studied the internal reproductive structures of *Siteroptes* (*Siteroptes*) *reniformis* Krantz and of an undescribed *Neopygmephorus.* In these species a duct, the *vas deferens,* connects the single *testis* to a globular chamber which probably functions as a combined *seminal vesicle* and *sperm pump.* This chamber is characterized by lateral winglike structures which are probably dilator muscles. The tubular *ejaculatory duct* connects the pump with the intromittent organ. In *S. reniformis,* while this duct appears superficially to open ventrally into the penis about halfway along the latter's length, closer inspection reveals that it doubles back to join the penis at its base, therefore allowing protrusion of that organ without imposing strain on the duct. In *Neopygmephorus* and *Imparipes* this reflexed portion is lacking and the ejaculatory duct is seen to enter the penial base. This arrangement is in keeping with the nature of the intromittent organ, which in these genera is long, flexible, and looped within the genital capsule.

Legs

The legs of male pyemotids may be quite similar to those of their respective females or greatly modified. Generally speaking, the similarities are most pronounced in *Dolichocybe*, least in *Neopygmephorus*. As in the females, and with but few exceptions, legs II and III are the principal locomotory appendages and are therefore thought to retain the least specialized form and setation.

Leg I invariably possess five segments, the setation of the tibia and tarsus closely following that believed by Krczal (1959b) to be primitive (fig. 12). In *Dolichocybe* tarsus I bears two claws, in *Trochometridium* it bears only a membranous flap, and in all remaining known forms, a single claw is present. Trochanter I resembles that of the female as regards setal number but setae *c* and *d* are always setiform.

The angle of articulation of legs I to the anterior ventral plate is the same in both sexes except in *Neopygmephorus* and the scutacarid genus *Imparipes*. In these genera coxa I of the male articulates at a right angle to the longitudinal plane of the body, while in the female it is distinctly oblique.

The relative length of the legs may differ greatly between sexes. In the male of *Neopygmephorus*, for example, leg I is much longer than leg II, while in the female the reverse is true.

Leg II of *Trochometridium* is distinctly larger than leg III. The setation, although similar to that of the female in number, differs distinctly in structure. These changes are probably correlated with the mating behavior of the male (see p. 126).

In *Resinacarus*, leg III is noticeably longer than II and has an elongate, spurlike seta lacking on the former. According to the original description (Vitzthum, 1927), only this leg differs greatly from its female counterpart.

Leg IV closely resembles that of the female only in *Resinacarus* and in *Dolichocybe*. It is distinctly stouter and shorter than its female homologue in *Acarophenax*, *Paracarophenax*, and *Trochometridium* and usually has at least one modified claw in addition. In the male of *Paracarophenax dermestidarum* (Rack) legs IV are distinctly larger than legs III, but the reverse is true in *Acarophenax tribolii*.

Legs IV are modified forcepslike in all remaining genera studied and are normally carried horizontally and directed toward the rear. Concomitant modifications may occur in the shape and size of the coxa or trochanter IV or both, a shortening of the tarsus, and the

simultaneous enlargement of one claw and dimunition or loss of the other. In addition, an accompanying increase in the strength of the posterior ventral apodemes usually takes place. Setation in these forms is similar to that of the female except that one or two tibial setae may be spinelike and that the tarsus may be lacking a seta.

IMMATURE STAGES

Insofar as known, members of the genera *Dolichocybe, Acarophenax, Paracarophenax, Pyemotes,* and *Trochometridium* possess no active immature forms, the adult mite being the only definitive postoval stage. Two free-living immature stages, the hexapod larva and one octapod nymph, have been reported in *Siteroptes graminum* (*vide* Reuter 1900, Cooper 1937, Alfaro 1946), but the appearance of the latter should probably be investigated more thoroughly since it seems likely that the "nymphs" are in reality young females. Fully developed larvae still within the chorion have been observed by the present author in mounted specimens of *Perperipes* and *Neopygmephorus.* In at least one species of the latter genus, the larval stage is not free and the nymphal stage is lacking, since the adult mite may be seen within the skin of the molting larva. This developmental sequence of egg → larva → adult also occurs in at least two species of the scutacarid genus *Imparipes* (G. Bohart and Cross unpublished), although in the latter genus the larval stage is free.

The larvae of two species of *Siteroptes* and a single species each of *Perperipes* and *Neopygmephorus* agree more closely with their males than with their females as concerns the configuration of the anterior ventral plate and the structure of the legs. In *Siteroptes,* however, larvae possess only four pairs of anterior ventral setae while both males and females have six pairs. Larvae of the above three genera further resemble males in lacking tracheae, peritremes, the pseudostigmata, and in possessing an extra pair of propodosomal dorsals which are probably homologues of the latter. Three hysterosomal terga are present and of normal size but the fourth and fifth are reduced and modified to form a pronounced terminal lobe. Setation of the first four segments resembles that of the female. The fifth segment bears at least two pairs of setae.

Although the anterior ventral plate closely resembles that found in the male, the setation and apodemes of the posterior ventral plate differ considerably from those of both adults as might be expected, due to the loss of a pair of legs from this plate.

Leg I is always five-segmented and is articulated to the anterior ventral plate at a right angle to the longitudinal axis of the body. As in the male, setae *c* and *d* of trochanter I are always setiform. Tibia and tarsus I resemble these segments of the male except that the latter always has two claws. Legs II and III likewise resemble those of the male.

PHYLOGENY

In view of the fragmentary knowledge of the Pyemotidae and related groups, this portion of the present work is preliminary. It is included as a beginning from which further speculation may develop.

The construction of a scheme of phylogeny properly supposes a knowledge of ancestral forms, but this is not possible in the Tarsonemoidea owing to the complete lack of a fossil record. Speculations concerning the relationships of the groups were therefore made by less satisfactory means.

The genera were first arranged into higher categories based upon the largest number of characters possible. These characters may be found in Tables III and IV, in the keys, and in the descriptions. Estimates of higher categories which were most closely related were then made by noting the intermediate genera, *i. e.*, genera in one tribe or subfamily sharing the largest number of characters with another tribe or subfamily. Such estimates are probably consciously or subconsciously a part of the procedure followed by most systematists and are usually used to deduce the supposed phylogenetic relationships. Static or phenetic relationships may be much more precisely defined in terms of correlation coefficients among species as done by Michener and Sokal (1957).

Characters were considered to be of two kinds with respect to their usefulness in determining relationship: (1) Those for which no assumptions of primitiveness or specialization were made, and (2) those for which inferences of primitiveness or specialization were made. The former are invariably characters arising within the group or characters whose homologues outside the Tarsonemoidea are uncertain. For example, a single pair of opisthosomal ventral setae is present in a few Pyemotinae, in all Acarophenacinae and Tarsonemidae, but is absent in the remaining Pyemotinae and in all Pygmephorinae and Scutacaridae. The homologues of these setae may or may not be any of a number of similarly located setae found in the groups considered to be most closely related to the

Tarsonemoidea, hence, by comparison cannot be considered to be either primitive or derived. Such characters are nevertheless valid in evaluating phenetic relationships. In a few cases (Table III, males only, and Table IV), particularly when they formed sequences of modification, they were used in association with other characters in the phylogenetic speculation.

Inferences as to the degree of primitiveness or specialization of characters thought to be useful in making phylogenetic assumptions were reached as indicated below:

(1) *By comparison of the various tarsonemoid taxa with non-tarsonemoids considered to be closely related.* For reasons to be mentioned later, the Anystoidea of Cunliffe (1955) are probably more closely related to tarsonemoids than are any other mites and are ancestral to them. The pyemotids of the Tarsonemoidea are most similar to the pseudocheylids of the Anystoidea. Comparisons of characters between members of these two superfamilies, and particularly between the two families mentioned, were considered to be more meaningful than similar comparisons made with groups thought to be more distantly related. Characters found in the anystoids but only some tarsonemoids are considered to be more primitive in the Tarsonemoidea than the alternative characters found only in the Tarsonemoidea. These comparisons present, however, several important difficulties, as follows: (a) Uncertainty does still exist as to the closest relatives of the Tarsonemoidea. The gap between tarsonemoids and anystoids is of sufficient size that explicit lines of descent cannot be recognized. (b) Any repetitive character (*i. e.*, one lost or modified, then regained) or any character that arose independently in different groups may produce similarities resulting from convergence or parallelism rather than phylogenetic relationship. Despite these difficulties, this method of recognizing primitive and derived characters is probably the most reliable and has been used herein wherever possible. Table III lists characters judged on this basis.

(2) *By extension of the premise that phenetic similarity implies relationship.* In certain cases where well-defined sequences of modification in the states (any one of the two-several alternative conditions possible) of a character were present, phenetic characters were used in the determination of phylogeny. In such cases, the sequences were present in two morphologically different lines as determined by numerous associated characters, and the primitive

end of the sequence was considered to be the end common to both. For example, a progressive change in the number of ventral propodosomal setae has occurred within the Pyemotidae. In most of the Pyemotinae six pairs occur but in the Pygmephorinae five and four pairs are the rule, and in the Acarophenacinae four, three, and two pairs are present. The latter number is characteristic of most Tarsonemidae (except for *Tarsonemella*). In this instance, the author has considered the primitive number to be six pairs. Characters whose primitiveness or specialization was determined in this fashion are listed separately in Table IV.

(3) *By a combination of methods 1 and 2 above.* The primitive and derived states of the characters listed for males in Table III were arrived at by combining the two methods above. In this case, anystoid males were not available for study but inferences drawn from comparisons of tarsonemoids with prostigmate forms considered to be more distantly related than anystoids agree with those drawn from observations of sequential modifications, present only in males, in which one extreme contained forms closely resembling the females but the other extreme consisted of forms strikingly different from them. There is, for example, a progressive reduction of the mouthparts followed by the reduction, then loss of the gnathosoma. A parallel sequence concerns certain great modifications of the opisthosoma and copulatory apparatus. In this case, it seems clear that the primitive characters are those most nearly alike in both sexes. Single series of sequential modifications, unless supported by evidence from other sources as in the case of the males above, were not considered in the speculations on the phylogeny.

In the Pyemotidae, certain characters are of special interest in that they appear highly specialized, yet occur only in the genera considered to be primitive. Extreme physogastry, for example, is found throughout the Pyemotinae, Acarophenacinae, and in most Pygmephorini. It is not known to be present in the Microdispini and Neopygmephorini (except in the microdispine genus *Perperipes*) and in the Scutacaridae. A closely related character, the number of active immature stages, follows a similar pattern. In certain pyemotines (*Dolichocybe, Trochometridium, Pyemotes*) as well as in the Acarophenacinae, all immature stages are supressed, the first active stage therefore being the adult. In *Siteroptes* and in all known Pygmephorinae as well as in the Scutacaridae, a definitive hexapod larval stage is interposed between egg and adult.

The occurrence of these unusual characters in forms believed closely related to the Pyemotidae has not been studied but partial physogastry in conjunction with the simultaneous production of at least eight eggs has been observed by the author in one gravid female teneriffiid. Despite their seemingly obvious specialization, such characters must be considered primitive *within the family*, and the return to the less extreme condition as derived. The same treatment is accorded characters which are lost, then regained, both loss and reappearance being considered as specializations.

Groups having a high percentage of the primitive characters listed in Tables III and IV are considered primitive, those having a high percentage of derived characters are considered to be specialized. Further judgment concerning the positions of the various taxa was made after consideration of habits and internal structures.

Table V lists for each subfamily and tribe, in the manner of Sinha (1958), the number of primitive, partially derived (derived in some, but not all species in a group), and derived characters from Tables III and IV. Males are listed separately because they are so poorly known. Table VI indicates the percentage of primitive characters listed in Table III possessed by representative species of each genus. Males are listed separately for the reason stated above.

Relationships of the Tarsonemoidea to other groups. Although at least two ideas regarding the relationships of the group have been popular in the past, all contemporary authors agree that the Tarsonemoidea should be placed in the Suborder Trombidiformes and that its members are most closely related to the Supercohort Prostigmata (see History). The recent discoveries of the primitive genera *Dolichocybe* and *Pavania* have, however, emphasized a possible relationship, hitherto unsuspected, between the Pyemotinae and the anystoid family Pseudocheylidae.

In general, anystoids resemble prostigmates and differ from tarsonemoids in that the cheliceral bases are freely developed and moveable, in possessing well-developed, segmented palps which usually retain the thumb-claw complex, in the position and size of the genital opening, the latter often furnished with suckers in the female, in genital setation, in usually having six or more leg segments, in lacking definite segmentation (although segmentally arranged plates may be present), in usually possessing eye spots, and because (usually?) the males resemble the females.

Alternatives of some of these characters peculiar to the Tarsone-

TABLE III.—List of Primitive and Derived Characters in the Pyemotidae

Primitive	Derived
A. FEMALES	
1. Gnathosoma free	Gnathosoma enclosed in propodosoma
2. Palps free	Palps fused to gnathosoma
3. Palps not elongate, not fitted for piercing	Palps elongate, fitted for piercing
4. Chelicerae small, distinct	(*a*). Chelicerae reduced, not or barely visible (*b*). Chelicerae enlarged, bladelike
5. Stigmata present	Stigmata absent
6. Pseudostigmata present	Pseudostigmata absent
7. Without well defined esophageal pump	Esophageal pump (*a*). in gnathosoma (*b*). in propodosoma
8. Gnathosoma directed forward	Gnathosoma directed at least anteroventrally
9. Propodosomal dorsum just meeting first hysterosomal margin	Propodosomal dorsum distinctly overlapping or being overlapped by first hysterosomal tergum.
10. Propodosoma not divided	Propodosoma divided into two parts
11. Hind margin of posterior ventral plate entire, plate lacking median triangular area	Hind margin of posterior ventral plate tripartite, plate with median triangular area
12. Posterior ventral plate whole	Posterior ventral plate divided longitudinally or transversely
13. Anterior genital sclerite indistinct	Anterior genital sclerite distinct
14. Posterior genital sclerites indistinct or variously shaped but not triangular and flaplike	Posterior genital sclerite triangular and flaplike
15. All legs with five segments	Legs I or IV with four segments
16. All coxae similarly shaped	At least coxae IV differing from the rest in shape
17. All tarsi with two claws	(*a*). Tarsus I with only one claw (*b*). Claws lacking on one or more pairs of legs
18. Seta *c* of trochanter I setiform	Seta *c* of trochanter I modified
19. Tarsus IV similar to tarsi II and III	Tarsus IV more or less elongate, distinctly longer than II or III
20. Claws II-IV alike, simple	Claws II and III basally dilate, often toothed in addition

TABLE III.—List of Primitive and Derived Characters in the Pyemotidae—*Concluded*

Primitive	Derived
A. FEMALES—*Concluded*	
21. Coxa IV not markedly bulbose basally	Coxa IV slightly to markedly bulbose basally
22. Mites pale, soft bodied	Mites sclerotized, harder bodied
B. MALES	
23. Gnathosoma present, well developed	Gnathosoma absent or at least greatly reduced
24. Mouthparts functional	Mouthparts non-functional
25. Genital capsule undeveloped	Genital capsule developed
26. Posterior ventral plate resembling that of female	Posterior ventral plate differing from that of female
27. Dorsal segments I-II distinct	Dorsal segments I-II fused
28. Legs I-III similar to those of female	Legs I-III differing from those of female
29. Legs IV straight, not greatly differing from II and III in length	Legs IV tonglike, often greatly shortened

TABLE IV.—Supplementary List of Primitive and Derived Characters in the Pyemotidae

Primitive	Derived
1. With six pairs of ventral propodosomal setae	With fewer than six pairs of ventral propodosomal setae
2. With three pairs of propodosomal dorsals	With fewer than three pairs of propodosomal dorsals
3. Segment V with more setae	Segment V with fewer setae
4. Posterior ventral plate with six pairs of setae	Posterior ventral plate with fewer than six pairs of setae
5. Trochanter I with four setae	Trochanter I with three or (rarely) five setae

moidea and believed to be derived are as follows: cheliceral bases are fused with the palpal bases to form a gnathosomal capsule in which only the moveable chela seems to function as a protrusible piercing organ, the palps are reduced with segmentation absent or indistinct, the distinct thumb-claw complex is lacking but a more or less palmate apical claw is often present, the female genital opening is apical, the legs possess five or fewer segments, and sexual dimorphism is present, usually marked.

The presence of well-defined body segmentation in the Tarsonemoidea has sometimes been regarded as primitive. Although certain primitive mites of the Anactinochitinosi (*e. g., Opilioacarus*) retain what may be primitive segmentation, there is no account of such segmentation in the Trombidiform-Sarcoptiform group, and in view of their many other seemingly specialized characters, such segmentation may well be secondarily acquired in the tarsonemoids.

Pyemotines resemble pseudocheylids in being elongate and weakly sclerotized, in the shape and position of the peritremes (lost, however, in *Pavania* and *Dolichocybe*) and of the pseudostigmata, in the shape, number of segments, type of pulvillus, and to a surprising degree, the setation of the legs, in lacking genital suckers, and in the setation of the propodosomal dorsum.

Relationships among the families within the Tarsonemoidea. Broad trends of the relationships within the Tarsonemoidea are seemingly plain and were outlined, sketchily, as early as 1901 by Brucker. It is generally agreed that the Pyemotidae are the most generalized family, being most similar to prostigmata and anystoids, and give rise, on the one hand, to the Tarsonemidae and Podapolipodidae, and on the other to the Scutacaridae. The origins of the first two are obscure but their closest living relatives are seemingly found in members of the genus *Pyemotes* and in the subfamily Acarophenacinae (see below). The Scutacaridae, on the other hand, are doubtless specialized forms arising from the Pygmephorinae of the Pyemotidae and are so closely related to them that their present family status may reasonably be questioned. Since females may be satisfactorily separated, and because such a separation simplifies the classification, it is retained herein.

Relationships within the family Pyemotidae. The family is here divided into the three subfamilies, the Pyemotinae, Acarophenacinae, and Pygmephorinae. Of these, the Pyemotinae has the smallest number of derived characters (Tables V and VI). All its mem-

TABLE V.—Number of Primitive and Derived Alternatives of Characters Listed in Tables III and IV

	Primitive	Partly derived	Derived
FEMALES			
Pyemotinae	17	10	0
Acarophenacinae	11	9	6
Pygmephorinae			
Pygmephorini	11	5	11
Microdispini	9	7	11
Neopygmephorini	10	3	14
MALES			
Pyemotinae	1	6	0
Acarophenacinae	3	0	4
Pygmephorinae	0	0	7

TABLE VI.—Per cent Age of Primitive Characters (From Table III) Possessed by Various Pyemotid Species

SPECIES	Percent primitive characters	
	Male	Female
PYEMOTINAE		
Pavania fusiformis	.....	82
Dolichocybe keiferi	100	96
Pyemotes sp.	56	76
Siteroptes macer	.....	91
Siteroptes prob. *graminum*	0	91
Siteroptes (*Siteroptoides*) sp.	0	86
Trochometridium tribulatum	44	76
ACAROPHENACINAE		
Caraboacarus sp.	.....	71
Acarophenax tribolii	56	48
Paracarophenax dybasi	56	48
Adactylidium beeri	.....	48
PYGMEPHORINAE		
Pediculaster americanum	.....	53
Pygnephorus (*spinosus* group)	.....	48
Microdispodides pholidotus	.....	48
Microdispus obovatus	.....	57
Myrmecodispus dorylinis	.....	57
Glyphidomastax rettenmeyeri	.....	53
Perperipes ornithocephala	.....	43
Peponocara cathistes	.....	57
Parapygmephorus halictinis	.....	48
Acinogaster marianae	.....	43
Neopygmephorus sp.	0	38

bers are characterized by five-segmented legs I (except in *Resinacarus*), three pairs of propodosomal dorsals, trochanter I with four setae, of which seta *c* is unmodified, and by coxa I articulating at a right angle to the longitudinal axis of the body. In addition, its presumably most primitive members may possess two claws on tarsus I, have coxa IV similar in shape to that of the remaining legs, have a pair of setae on the opisthosomal venter, and possess (at least in *Dolichocybe* and *Pyemotes*) males having a well-developed gnathosoma, functional mouthparts, and relatively unmodified sexual structures and hind legs.

The subfamily Acarophenacinae consists of a unique group whose members possess only four of the specialized characters listed in Tables III and IV. It shows closest affinities to primitive pyemotine genera in that the adjacent margins of the propodosoma and hysterosoma are contiguous or nearly so, in having a pair of opisthosomal ventral setae (except in *Caraboacarus*), in that coxa IV resembles that of the remaining legs, in the shape and extent of the ventral apodemes, in that the palps may be fused and the chelicerae large, and in the presence of the gnathosoma and relative lack of modification of sexual structures in the male. Except for the genus *Caraboacarus,* the subfamily forms a morphologically distinct group based on the loss of ventral setae, the loss of pseudostigmata, the loss of claws, and in having the male genital opening situated ventrally. *Caraboacarus* alone resembles the more primitive pyemotines in that leg I is five-segmented, in having pseudostigmata, in having the gnathosoma free and not recessed into the propodosoma, and in having the propodosoma entire rather than bipartite. More specialized Acarophenacines resemble the higher pyemotines in having legs I with four segments, trochanter I with three setae, claw I sometimes greatly enlarged and sessile, tarsus I sometimes with a mediolateral sensory spot, and legs I arising oblique to the longitudinal axis of the body. These characters are thought to have been independently derived. All species of acarophenacines whose habits are known are parasites of insects or their eggs.

In the reduction of the ventral setae but retention of the opisthosomal ventrals, in the structure of the ventral apodemes, shape and structure of the propodosoma, position of the stigmata, general size and shape, and in the retention of a functional gnathosoma in the male, members of the Acarophenacinae resemble, and are thought to be closely related to, members of the family Tarsonemidae. The

origin of the highly specialized Podapolipodidae is less clear but is probably closest to the tarsonemid-acarophenacine groups. No seemingly primitive members of the Podapolipodidae were available for study and observations of specialized forms, *e. g.*, *Podapolipus*, give little information as to their derivation.

Despite the apparent difference in the number of derived characters between the two groups (due to the fact that some, but not all pyemotines possess derived characters found throughout the Pygmephorinae; see Table V), the distinction between the Pyemotinae and Pygmephorinae is not well defined, a gradual transition occurring between the two groups. The point of division between them is therefore arbitrary and is based upon few characters. Weighting of characters (number of segments of leg I, conformation of seta *c* of trochanter I) has therefore been done deliberately in this case with an eye toward simplification of the classificatory structure.

The relationships of the Pygmephorinae have been obscured by earlier authors, who assigned all known species except the two belonging to the hitherto monotypic genera *Microdispodides* and *Microdispus* to the single genus *Pygmephorus*. Because of the close relationship between the two groups, primitive pygmephorines of the tribe Pygmephorini (the latter containing 11 derived characters) share the following characteristics with at least some specialized members (*e. g.*, *Siteroptes*) of the subfamily Pyemotinae: extreme physogastry, three pairs of propodosomal dorsals, vestiges of the intersegmental line between tibia and tarsus I, four setae on trochanter I, at least apodemes III and IV complete and well developed, apodeme V often present in addition, and leg I articulating more or less at a right angle to the longitudinal axis of the body. All of these characteristics are lost within various members of the tribe, but the last-named is found again, perhaps acquired secondarily, in certain members of the genus *Pseudopygmephorus* of the Neopygmephorini.

The tribes Microdispini and Neopygmephorini are considered almost equally specialized, their origins obscure but near the Pygmephorini. The former contains 11 derived characters, the latter 14.

Microdispines are characterized in that seta *c* of trochanter I is setiform and in having lost, except in some *Premicrodispus*, the second pair of propodosomal dorsals as well as a pair of setae from hysterosomal segment V. In most forms (exception, *Peponocara*)

the gnathosoma is elongate and often acuminate, the peritremes are widely separated and troughlike or guttate and the first hysterosomal segment is well developed, usually covering at least the posterior half of the propodosoma. As indicated by general body conformation, the articulations of coxae I, the shape and placement of the ventral apodemes, and the tripartite posterior margin of the posterior ventral plate, some *Microdispus* (*Premicrodispus*) show many characters in common with certain species of *Pseudopygmephorus* but the relationship between the two genera is obscure. The former is considered herein to be the most primitive from within the Microdispini while those forms associated with army ants and culminating with *Glyphidomastax and Perperipes* are thought to be the most specialized. These latter forms are characterized by the hyperdevelopment of the first hysterosomal tergum, the loss of claws from as well as other modifications of leg IV, the elongation of the palps for piercing, and other specializations. Phenetic relationships within the members of the Microdispini are easily established but phylogenetic relationships are obscure.

Most members of the Neopygmephorini differ from those of the Pygmephorini, as well as from most of the Microdispini, in possessing two, rather than one or three pairs of propodosomal dorsals. In addition, seta *c* of trochanter I is bladelike in all forms. Because of the multiple loss and reappearance of many characters, the relationships among the members of this tribe are not clear.

Figure 6 illustrates the author's concept of the relationships within the Tarsonemoidea in accordance with the outline presented above. The horizontal arrangement of categories is a matter of convenience.

DESCRIPTION OF THE FAMILY PYEMOTIDAE

Females

DESCRIPTION. Small mites, 85 to 400μ long, of varying shapes; color pearly-white translucent to brown; chelicerae styliform, enlarged bladelike, or (rarely) vestigal; peritremes usually dorsal and of various shapes, rarely (some Microdispini) in "shoulders" and directed anteriorly, or absent (only in *Pavania* and *Dolichocybe*); propodosomal dorsum entire or bipartite, bearing one to three pairs of setae; pseudostigmata usually present; anterior ventral plate with two to six pairs of setae; with four visible dorsal segments bearing, respectively, two, one, one or two, and two pairs of setae; fifth segment usually present, commonly enclosed by fourth, bearing zero to three pairs of setae; first tergum overlapped by, contiguous

with, or overlapping propodosoma, latter condition present to varying degrees but only rarely (*Perperipes, Glyphidomastax*) with free margins which cover the gnathosoma and basal segments of legs I and II; posterior ventral plate with three to six pairs of setae, opisthosomal venter with one pair or none; four pairs of legs always present; legs I four or five segmented, bearing zero to two claws, pulvillus of this leg usually lacking (present only in *Pavania* and *Dolichocybe fusiformis*); seta *c* of trochanter I often modified; leg IV with five segments (tibia and tarsus fused but distinct in *Caraboacarus*) and usually with claws; coxa III usually shorter than coxa IV; trochanter IV invariably much longer than femurogenu IV.

Present knowledge concerning males is too incomplete to merit a formal description; information concerning them can be found on pp. 68-73 (morphology), in the key to the genera of the subfamily Pyemotinae, and in the various descriptions.

Key to the Families of the Tarsonemoidea (Females)

1(*a*). Hind coxa and trochanter short, each much less than half as long as the greatly elongate and cylindrical femurogenu; hind tarsus without claws, terminating in two elongate, whiplike setae; coxa III elongate, always at least twice as long as coxa IV ..... *Tarsonemidae*

1(*b*). Hind coxa and trochanter longer, each always much more than half as long as femurogenu; hind tarsus present or not and with or without claws; coxa III never more than one and one-half times as long as coxa IV 2

2(*a*). Usually with three pairs of legs or less; if four pairs are present, then the gnathosoma is free and distinct and the propodosoma is not bipartite; pseudostigmata lacking ..... *Podapolipodidae*

2(*b*). With four pairs of legs; pseudostigmata present or, if lacking, then gnathosoma partly or completely enclosed within propodosoma 3

3(*a*). First hysterosomal tergum greatly expanded anteriorly and laterally so that its free, striate margins project over the gnathosoma and basal segments of legs I and II; segment V with three pairs of setae; seta *c* of trochanter I modified or absent; usually brown, circular to broadly elliptical in dorsoventral aspect ..... *Scutacaridae*

3(*b*). First hysterosomal tergum of varying shapes and sizes, but as described above only in two genera (*Perperipes, Glyphidomastax*) associated with doryline ants; if margins enlarged, free, and striate, then seta *c* of trochanter I setiform, segment V with two pairs of setae, gnathosoma greatly elongate, palps sharply acuminate ..... *Pyemotidae*

Key to the Subfamilies of Pyemotidae (Females)

1(*a*). With three pairs of anterior ventral setae or less; pseudostigmata often absent; chelicerae enlarged, distinct; opisthosoma short, usually not longer than distance between anterior margin of coxa III and posterior margin of coxa IV; mites oval or rhomboidal in dorsoventral aspect .... *Acarophenacinae*, p. 129

1(*b*). With at least four pairs of anterior ventral setae; pseudostigmata present; chelicerae usually small, indistinct; opisthosoma usually distinctly longer than distance between anterior margin of coxa III and posterior margin of coxa IV; mites variously shaped but only rarely oval or rhomboidal 2

2(*a*). Leg I usually with five segments, if four then coxa IV triangular (*Resinacarus*); coxa I articulated to anterior ventral plate at a right angle to longitudinal axis of body or nearly so; seta *c* of trochanter I setiform ..... *Pyemotinae*, p. 86

2(*b*). Leg I with four segments; coxa IV quadrate or rectangulate; coxa I articulated as above or distinctly obliquely; seta *c* of trochanter I setiform or not ..... *Pygmephorinae*, p. 147

Subfamily PYEMOTINAE

DESCRIPTION OF NON-GRAVID FEMALE. Mites of small to moderate size, 150 to 400μ long; shape, elongate-elliptical, elliptical, or fusiform; posterior margin of hysterosoma evenly rounded, broadly rounded, or truncate; integument weakly to moderately sclerotized, lacking striae, pebblings, or scalelike engravings.

Gnathosoma. Always free, normally directed anteriorly or rarely anteroventrally, never largely or completely hidden within propodosoma; palps fused to gnathosoma or free and moveable; chelicerae enlarged and distinct or small and indistinct.

Propodosoma. Dorsum. Always entire, pseudostigmata present; three pairs dorsal propodosomal setae; posterior margin of propodosoma only meeting, barely overlapping, or barely overlapped by anterior margin of first hysterosomal tergum; esophageal "finned" structures present or absent. *Venter.* Anterior ventral plate with four to six pairs of setae.

Hysterosoma. Four to five visible segments, segment V completely enclosed dorsally and posteroventrally by tergum IV or not; segment V with one to three pairs of setae; posterior portion of vaginal wall sclerotized or enclosed in enlarged, elliptical to globose pumplike structure or not; at least one genital sclerite present, its shape variable; opisthosoma not distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV, or if so, then body usually elongate; opisthosomal venter with or without single pair of setae.

Legs. Leg I four (rarely) or five-segmented, if four-segmented then coxa IV triangulate; coxa I, as seen from beneath, articulated at a right angle to the longitudinal axis of the body or nearly so; claws present on legs I to IV; trochanter I with four to five setae, seta *c* setiform; pinnacula absent; coxa IV triangular, quadrate, or rectangulate.

Key to the Genera of the Subfamily Pyemotinae

1(*a*). Males....7
1(*b*). Females....2
2(*a*). Leg I with two claws; peritremes lacking....6
2(*b*). Leg I with one claw; peritremes present....3
3(*a*). Leg I with four segments, tibia and tarsus fused....*Resinacarus*, p. 128
3(*b*). Leg I with five segments, tibia and tarsus separate....4
4(*a*). Coxa IV as coxa III, triangular; palps fused to gnathosoma (fig. 21) *Pyemotes*, p. 93
4(*b*). Coxa IV rectangular or quadrate; palps free....5
5(*a*). Posterior ventral plate tripartite; claw I sessile (fig. 29).... *Trochometridium*, p. 116
5(*b*). Posterior ventral plate entire; claw I distinctly pedicellate.... *Siteroptes*, p. 101
6(*a*). Palps arising ventrolaterally from gnathosoma; chelicerae large, falcate....*Pavania*, p. 87
6(*b*). Palps arising laterally from the gnathosoma; chelicerae small, indistinct....*Dolichocybe*, p. 89
7(*a*). Tibia III with greatly enlarged spinelike seta which reaches tip of tarsus or nearly so....*Resinacarus*
7(*b*). Tibia III lacking such a seta....8
8(*a*). Gnathosoma well developed, or if reduced, functional (figs. 15, 23)...9
8(*b*). Gnathosoma reduced to a lobe, mouthparts lacking (figs. 27, 99)...10
9(*a*). Leg I with two claws; leg IV normal (fig. 15)....*Dolichocybe*
9(*b*). Leg I with a single claw; leg IV modified, tonglike....*Pyemotes*
10(*a*). Leg I with single pedicellate claw; propodosomal dorsum with four pairs of setae....*Siteroptes*
10(*b*). Leg I with only broad, flaplike pulvillus; propodosomal dorsum with three pairs of setae....*Trochometridium*

Pavania Lombardini

(Figs. 17-18)

Pavania Lombardini, 1949, Redia (Firenze), 34: 67-74. Type, *Pavania fusiformis* Lombardini, 1949, by original designation.

This monotypic genus is very closely related to *Dolichocybe* Krantz, resembling the latter in that the peritremes are lacking or at least not visible, in that the opisthosomal plate is bipartite, each portion bearing an indentation or suckerlike structure, in the structure and conformation of the terminal opisthosomal segments, in the conformation of the coxae, in lacking coxal setae, and in posessing two claws on leg I. It differs from *Dolichocybe* in various gnathosomal characteristics, chiefly in the structure and size of the chelicerae and in the position and size of the palps. Members of both genera are considered to be among the most primitive of known pyemotids.

Only the non-gravid females are known.

DIAGNOSIS. Females separable from those of all other genera except *Dolichocybe* in possessing two claws on leg I and because they lack visible peritremes. They differ from those of *Dolichocybe* in that the palps arise ventrally rather than laterally and because the chelicerae are greatly enlarged and falcate.

DESCRIPTION OF NON-GRAVID FEMALE. Length, approximately 120μ; width, approximately 68μ; distance between anterior sternocoxal condyles of coxae III, approximately 47μ; body moderately sclerotized, coarsely punctate.

Gnathosoma. Elliptical in dorsal aspect, only slightly longer than wide, directed anteriorly; palp subconical, movable, arising from the ventral surface, bearing distinct apical tooth and two small ventral solenidia; chelicera greatly enlarged, falcate; ventral pharyngeal-esophageal pump absent, a series of beadlike esophageal structures present.

Propodosoma. Dorsum. Inversely U-shaped, expanding laterally at points of articulation of legs I and II; foramen opening anteriorly; posterior margin meeting but not projecting over or covered by first hysterosomal tergum; pseudostigmata present, located in anterior one-third, external pseudostigmatal socket subquadrate in shape; posterior pseudostigmatal setae at least twice as long as either of two remaining pairs; peritremes not visible, probably absent; distinct esophageal "finned" structures lacking in propodosoma. *Venter.* Anterior ventral plate with six pairs of setae, ventrites I and II each with three pairs; external ventral I not forked; apodemes II increasingly distinct at the sides, bending posteriorly near the midline, incomplete; anterior median apodeme complete, distinct; each posterior marginal apodeme indistinctly arcuate; band of pleated conjunctiva present ventrally between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment entire, meeting but not overlapping propodosomal dorsum; fourth segment enclosing fifth and closely associated with it, bearing two pairs of setae, one pair very long; fifth segment reduced, ventral, bearing large, slitlike vulva, the latter flanked by one pair of short setae. *Venter.* Posterior ventral plate elongate, entire, well defined anteriorly, bearing six pairs of setae; hind margin of posterior ventral plate entire, broadly rounded; second axillary arising from apodeme IV immediately mesad of anterior sternocoxal condyle IV; external presternals well behind and slightly laterad of internal presternals;

external poststernals close behind but well mesad of posterior margin of fourth coxal foramina; apodemes III distinct, procurved, not reaching midline; apodemes IV strongest laterally, weakly sigmoid, directed anteromesally; apodemes V lacking; posterior median apodeme weak, barely furcate posteriorly, terminating on level with internal presternals; opisthosoma (dorsally between segments III and IV, ventrally behind the posterior ventral plate and behind the opisthosomal venters) with bands of pleated conjunctiva; opisthosomal venter divided, forming two lateral "ears," each bearing a single seta and an oval, granulose disc; an antevulvar plate present in front of segment V, bearing two pairs of tiny setae and an internal sclerite; opisthosoma distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV.

Legs. Rather stout; leg I slightly longer and distinctly thicker than leg II, five-segmented; tarsus I rectangulate, narrower than femurogenu I; lateral sensory spot absent; claws I paired, sessile, moderately developed, not dilate basally, a short, flaplike pulvillus present between them; trochanter I with four setae; trochanter II with two setae, femurogenu II with one; trochanter III with one seta, femurogenu III with one; tarsi II and III each with six tactiles; solenidium of Tibia III absent; claws II-IV moderately stout, simple, subequal in size; pulvilli II-IV well developed, longer than claws; coxa III and IV similar in size and shape, elongate-triangular when viewed in inner ventral aspect; tarsus IV similar in size and shape to tarsus III; ratio of femurogenu IV to tarsus IV approximately 1 to 1.7.

Habits. Unknown. Known only from *Scarabaeus sacer* L. (Coleoptera, Scarabaeidae).

Distribution. Known only from the type locality.

Specimens Examined. *P. fusiformis,* Tortona, Italy, June, 1947, on *Scarabaeus sacer* L. (Syntypes).

Dolichocybe Krantz

(Figs. 13-16)

Dolichocybe Krantz, 1957, Ann. Ent. Soc. Amer., 50: 259-264. Type, *Dolichocybe keiferi* Krantz, 1957, by original designation.

As mentioned previously (p. 87), this genus shows a close relationship to *Pavania* Lombardini. It is retained herein largely because of the structure of the chelicerae and palps.

The author has not seen the form described as *P. fusiformis* by Krczal (1959b, p. 565) but comparison of its description with syn-

types of *fusiformis* indicates that it is a new species which is here tentatively placed as a second species of *Dolichocybe* until further work clarifies the status of these two genera.

In addition to the females of both species, gravid females and males of *D. keiferi* are known.

DIAGNOSIS. Both sexes are immediately separable from all other members of the family except *Pavania* because tarsus I bears two claws. Females differ from those of *Pavania* in that the palps arise laterally from the gnathosoma and because the chelicerae are small and needlelike rather than enlarged and falcate.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 140 to 190μ; width, 40 to 65μ; distance between anterior sternocoxal condyles of coxa III, 28 to 32μ; hysterosoma elongate-elliptical to subcylindrical; body very weakly sclerotized, without coarse punctae.

Gnathosoma. Ovate or elongate-rectangulate, normally directed anteriorly; palp palmate or elongate, if as latter, then cylindrical, bearing four to five short tactile and sensory setae, the most distinct of which is apical and falcate; palp movable but articulations indistinct; chelicera minute, indistinct; large, irregularly elliptical circumesophageal mass indistinctly present, this not distinctly ventral or bulbose as described for *Pyemotes;* esophagus narrow, straight, often indistinct.

Propodosoma. Dorsum. Rounded or oval, expanding laterally at points of articulation of legs I and II, anterior margin forming cylindrical "cervix" which encloses only gnathosomal base; foramen anterior, foraminal collar absent; posterior margin meeting but not prejecting over or covered by first hysterosomal tergum; pseudostigmata present, located in anterior one-third; posterior pseudostigmatal setae at least twice as long as either of other pairs; peritremes not visible, probably absent; esophageal "finned" structures absent. *Venter.* Anterior ventral plate with six pairs of setae, ventrites I and II each with three pairs; external ventral I not forked; apodemes II weak, often indistinct, gently arcuate posteriorly, incomplete medially; median apodeme appearing excavated groovelike; posterior marginal apodemes indistinct; large band of pleated conjunctiva present ventrally between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment entire, meeting but not overlapping propodosomal dorsum; fourth segment enclosing apex

of hysterosoma, bearing two pairs of setae, one pair very long; fifth segment closely associated with fourth, reduced, ventral, bearing vulva, the latter flanked by a pair of short setae; antevulvar plate present ventrally in front of segment V, bearing two pairs of tiny setae and an internal sclerite. *Venter.* Posterior ventral plate elongate, poorly defined anteriorly; median trigonal portion of posterior ventral plate lacking but latter indistinctly divided into three sections, (fig. 13 and Krczal, 1959b. p. 566) the two anterior each surrounding one of coxae III, the posterior enclosing both of coxae IV (the margins of these sections do not correspond to the ventral apodemes, which are separately distinct); posterior ventral plate with six pairs of setae, its hind margin produced mesally into a flap-like lobe; second axillary arising from apodeme IV immediately before the anterior sternocoxal condyle of leg IV; external presternals well behind and slightly laterad of internal presternals; external poststernals close behind but well mesad of posterior margin of fourth coxal foramina; apodemes III short, recurved posteriorly, not reaching midline; apodemes IV equally short, directed nearly mesad; apodemes V lacking; posterior median apodeme absent; opisthosoma (dorsally between segments III and IV, ventrally behind the opisthosomal venter) with a wide band of distinctly pleated conjunctiva; opisthosomal venter divided, forming two lateral "ears" which join but do not fuse with median lobe of posterior ventral plate, each piece bearing a single seta and an anteromedian depression; opisthosoma shorter than or as long as distance between anterior margin of coxa III and posterior margin of coxa IV.

Legs. Short and slender; leg I slightly longer and distinctly thicker than leg II, five-segmented; tarsus I rectangulate, never wider than femurogenu I; lateral sensory spot absent; claws I paired, sessile, moderately developed, not dilated basally, pulvillus present or lacking; trochanter I with four setae, seta *c* long, setiform; trochanter II with two setae, fermurogenu II with one; trochanter III with one seta, femurogenu III with one; tarsi II and III each with five tactiles; solenidia of tibiae II and III absent; claws II to IV simple, subequal in size; pulvilli II to IV well developed, longer than claws; coxa III elongate-triangular when viewed in inner ventral aspect; coxa IV similar in shape to coxa III but slightly larger; tarsus IV short, rather abruptly constricted basad of pretarsus; ratio of femurogenu IV to tarsus IV approximately 1 to 2.7.

DESCRIPTION OF GRAVID FEMALE (based only on *D. keiferi* Krantz). Gnathosoma and propodosoma as described for non-gravid female but entire hysterosoma becoming physogastric, globular; diameter of hysterosoma of slide-mounted specimens containing eggs, 245 to 400μ.

DESCRIPTION OF MALE (based only on *D. keiferi* Krantz). Length, approximately 105 to 115μ; width, approximately 60 to 65μ; hysterosoma ovate; conjunctival areas not granulose.

Gnathosoma. Subglobose, well developed, apparently functional, chelicerae indistinct but palp and internal pumplike structure at least partly distinct.

Propodosoma. Dorsum. Similar to that of female but much broader, bearing four pairs of setae in approximately same location to each other as in female. *Venter.* Similar to that of female.

Hysterosoma. Dorsum. Four visible dorsal segments, the first bearing two pairs of setae, the second one, the third two, the fourth three; fifth segment ventral. *Venter.* Posterior ventral plate similar to that of female but lacking median posterior lobe; hysterosomal venter apparently fused with segment V, the combined sclerites bearing four pairs of setae, acuminate posteriorly, aedeagus apparently opening at apex, aedeagal armature indistinct, perhaps lacking; well defined genital capsule or specialized clasping structures lacking; internal triangulate structure (vesicula seminalis?) prominent between aedeagal duct and vas deferens.

Legs. Unmodified, generally shorter but otherwise similar to those of female.

Habits. The only published information concerning the habits of *Dolichocybe* is found in the description of *D. keiferi.* Krantz (1957) states that the females give birth to active adult males and females. Gravid females were found under the bark of *Acer palmatum* Thunb. "at approximately the cambium." The limbs of the tree from which the type series was taken were dying but the relationship of the mites, if any, to this condition was not known. A series of gravid females taken from the "tunnel of a wood borer" have been seen by this author. They indicate a more probable parasitic method of existence. The form designated as *P. fusiformis* by Krczal is recorded by that author from *Scarabaeus sacer* L. and *Tatropium gabrieli.*

Because of the relatively unmodified posterior portions of the male body, it is probable that at least males of *D. keiferi* do not

grasp and carry the females about prior to and during copulation as is the habit of the higher pyemotids.

Distribution. *D. keiferi:* Known from Arizona, California, Washington, and Puerto Rico. "*D. fusiformis*" of Krczal: Known from Italy and France.

Specimens Examined. *D. keiferi*, from Arizona, Washington, California (Syntypes), and Puerto Rico, taken from the following hosts or situations: *Acer palmatum*, custard apple, from beneath apple bark, and in tunnel of wood borer in red bud.

Forms thought to belong to *Dolichocybe* Krantz:

keiferi, Krantz, 1957
Pavania fusiformis, Krczal, 1959, *not P. fusiformis* Lombardini, 1949

Pyemotes Amerling

(Figs. 21-24)

Heteropus Newport, 1850, Proc. Linnean Soc. London, 2:70 (*nom. praeocc.* in Insecta, Palisot-Beauvois, 1805). Type, *Heteropus ventricosus* Newport, 1850, by original designation.

Pyemotes Amerling, 1862, Česka Společnost Nauk, Prague, 1862, p. 54. Type, *Piemotes Eccoptogasteri pruni* Amerling, 1862, *nomen nudum* = *Heteropus ventricosus* Newport, 1850, by designation of Oudemans, 1937.

Lais DeFilippi, 1862, Archivio per la Zoologia, l'Anatomia e la Fisiologia, 1(2): 211-215, Tav. XIV (*nom. praeocc.* in Tunicata, Gistel, 1848). Type, *Lais heterogyne* DeFilippi, 1862, by original designation.

Physogaster Lichtenstein, 1868, Bulletin Entomologique. Seánces de la Société Entomologique de la France, (4)8: LXXXVI (*nom. praeocc.* in Insecta, Lacordaire, 1830). Type, *Physogaster larvarum* Lichtenstein, 1868, by original designation. *larvarum* = *nomen nudum* Oudemans, 1936.

Pediculoides Targioni-Tozzetti, 1878, Annali dell'Agricoltura, 1:241. Type, *Acarus tritici* LaGrèze-Fossot and Montané, 1851, Rec. Agronomique de la Société des Sciences, Agriculture, et Belles Lettres, 32(2), by original designation, *not Pediculoides tritici* Targioni-Tozzetti, 1878.

Crithoptes Geber, 1879, Wiener Medizinische Presse, 20(43): 1429. Type *Crithoptes monunguiculosis* Geber, 1879, by original designation.

Sphaerogyna Laboulbène and Megnin, 1885, Journal de l'Anatomie et de la Physiologie Normales et Pathologiques de l'Homme et des Animaux, 21:14. *Nom. nov. for Heteropus* Newport, 1850.

Physacarus Trybom, 1893, Entomologisk Tidskrift, 14: 121-126. *Nom. nov.* for *Heteropus* Newport, 1850.

Phthiroides Oudemans, 1936, Festschrift für Embrik Strand, 1: 403. Type, *Phthiroides megnini* Oudemans, 1936, *nom. nov.* for *Sphaerogyna ventricosa* (Newport) Laboulbène and Megnin, 1885, *not Heteropus ventricosus* Newport, 1850.

Members of this genus are among the best known of all Acarina. At least one species is a parasite of larval Lepidoptera in various stored grains, in which it may form large populations, these swarming to attack handlers and carriers of the infested material. The

bite causes mild to severe cutaneous reactions, always accompanied by severe itching and sometimes by nausea and other symptoms. The erruption resulting from a number of bites has been confused with scabies, chicken pox, and other diseases. Severely infested grain has been reported fatal when fed to chickens (see Schamberg, 1910). This paper will not deal with the medically important aspects of *P. ventricosus* and related forms since they have been well reviewed by several authors. A nearly complete bibliography of the literature extant in this area is available from the author upon request.

Attempts to utilize a species of *Pyemotes* in the biological control of the boll weevil were unsuccessful (Hunter and Hinds, 1905).

Although the author follows Oudemans (1936), in placing at least four forms in the genus, it seems improbable that host specificity is as restricted as believed by that author. Lichtenstein [1868, (*in* Webster, 1883)], and Herfs (1926), recorded a *Pyemotes* attacking larval Hymenoptera, Coleoptera, and Lepidoptera indiscriminately, and the latter author deliberately cultured the parasite successfully on various hosts. (For detailed listings of hosts, see Herfs, 1926.) More recently Krczal (1959a), describes *P. boylei*, mentioning that it is an efficient parasite of both the anthribid *Araecerus levipennis* Jordan, and of the termite *Cryptotermes brevipennis* Walker.

Because of the medical importance of the genus numerous publications have appeared which are concerned with its bionomics. Probably the most notable are the works of Brucker (1901), Herfs (1926), Monterosso (1934), and Krczal (1959b). Pätau (1936), has made detailed cytogenetic studies of one species.

DIAGNOSIS. Females may be separated from all others in the family except *Trochometridium* because the posterior ventral plate is tripartite, its median section elongate and triangular. They are distinguished from *Trochometridium* in that coxa IV is triangular in the manner of coxa III, because the palps are fused to the gnathosoma, and by the presence of a pair of opisthosomal ventral setae.

DESCRIPTION OF NON-GRAVID FEMALE. Length, approximately 200 to 325μ; width, approximately 70 to 125μ; hysterosoma elongate, cylindrical to fusiform or rarely rhomboidal; body weakly to lightly sclerotized and without coarse punctae.

Gnathosoma. Subglobose to ovate, usually large, normally directed anteriorly; palps fixed, fused to gnathosoma; anterior mar-

gins of gnathosoma protruding slightly, truncate or gently rounded, anterior extremity of ventral margin marked by second palpal setae; chelicera stout, distinct, aciculate; esophageal pharyngeal pump prominent; dorsobasal "tentorium" ("*Chitinspangen*" of Krczal) also well defined.

Propodosoma. Dorsum. Trapezoidal to sagittate, lateral margin sinuate, anterior margin often projecting over gnathosoma, indistinct; foramen opening anteriorly, foraminal collar absent; posterior margin projecting slightly to distinctly over the anterior margin of first hysterosomal tergum; pseudostigmata present, located in middle third; three pairs of propodosomal setae, posterior pseudostigmatal pair at least twice as long as either of others; peritremes dorsal, divergent, their elliptical openings near laterobasal angles of gnathosoma; esophageal "finned" structures absent. *Venter.* Anterior ventral plate with four pairs of setae, (Oudemans, 1936, probably erroneously, describes *P. fortuitus* as having but two pairs) ventrites I and II each with two pairs; ventral externals I not forked; coxa I attached at a right angle to longitudinal axis of body or slightly obliquely; apodemes II straight or weakly arcuate, complete or incomplete medially, their mesal terminations never suddenly bending posteriorly; anterior median apodeme distinct, complete; posterior marginal apodemes absent or indistinct except laterally; distinct band of conjunctival pleats absent between propodosoma and hyterosoma.

Hysterosoma. Dorsum. First segment entire, its anterior margin slightly to distinctly hidden beneath hind margin of propodosoma; cuticular attachments of dorsoventral muscles distinct anterior to dorsal setae II and III; fourth segment bearing two pairs setae, partially enclosing apex of hysterosoma; fifth segment reduced, normally visible only ventrally, bearing a single pair of ventral setae and the apical vulva. *Venter.* Posterior ventral plate elongate, poorly defined anteriorly, tripartite, possessing a large, distinct, median, trigonal area; posterior ventral plate with five pairs of setae; first axillary on or slightly posterior to apodeme III, always mesad of coxa III, second axillary well mesad of anterior sternocoxal condyle IV; external presternal well behind and usually only slightly lateral to internal presternal; one pair of poststernals, these arising from medial trigonal sclerite approximately on line drawn between posterior margins of coxae IV; apodemes III and IV short, the former gently arcuate, the latter gently sigmoid, neither reaching

trigonal area; median apodeme absent; opisthosoma with wide band of distinctly pleated conjunctiva dorsally between segments III and IV, ventrally between the opisthosomal venter and segment V; opisthosomal venter entire, bearing a single pair of setae.

Legs. Usually slender, moderately elongate; leg I about as long as and distinctly thicker than leg II, five segmented; tarsus I quadrate to subconical, never wider than femurogenu I; lateral sensory spot absent; claw I arising from a short, stout pedicel, often appearing sessile or nearly so; thumb prominent to absent; trochanter I with four setae, seta *c* long-setiform; trochanter II with three setae, femurogenu II with three; trochanter III with two setae, femurogenu III with three; tarsi II and III each with five to seven tactile setae, solenidium of II near middle of segment, solenidia of tibiae II and III present or absent; claws II to IV simple or with weak basal spur, subequal in size; pulvilli II to IV well developed, longer than claws, coxa III elongate-triangular when viewed in inner ventral aspect; coxa IV similar in shape to coxa III but shorter and stouter; tarsus IV short, not or slightly longer than tarsus III, constricted abruptly basad of pretarsus; ratio of femurogenu IV to tarsus IV, approximately 1:2.0 to 1:2.5.

DESCRIPTION OF GRAVID FEMALE. Externally as in non-gravid female but opisthosomal conjunctival bands unpleating to form turgid, milky globe which may reach 2 mm. in diameter; segments IV and V visible and adjacent at apex of globe.

DESCRIPTION OF MALE (based only on males of one species in collection of author plus description of *P. boylei* Krczal, 1959a). Length 190 to 200μ; width, approximately 100 to 120μ; hysterosoma ovate; conjunctival areas not granulose.

Gnathosoma. Rounded, well developed, functional; palpi fused to gnathosoma as in female; chelicerae reduced but distinct, needle-like; esophageal-pharyngeal pump well defined.

Propodosoma. Dorsum. Large, trapezoidal or with sides sinuate, bearing three or four pairs setae, if four then fourth pair tiny, slightly anterior to and well mesad of anteriormost of remaining setae. *Venter.* Similar to that of female but shorter.

Hysterosoma. Dorsum. Dorsal segmentation modified, first plate subcircular, bearing three pairs setae, second reaching genital capsule (*"Kopulationsapparat"* of Krczal, 1959b), bearing but a single pair; posteriormost portion of body constricted to form capsule, this concave posteriorly, bearing single short pair of dorsal setae.

Venter. Apodemes III, IV, and V well developed, posterior median apodeme absent; setation of posterior ventral plate similar to that of female; opisthosomal venter not visible as definitive sclerite; one or two pairs of setae ventrally on genital globe; genital capsule with one dorsal pair and one ventral pair of suckerlike structures; aedeagus tubular, well sclerotized.

Legs. All legs five-segmented; legs I and II similar to those of female but shorter; leg III distinctly longer than I, II, or IV, coxa IV subquadrate, trochanter IV distinctly arcuate, width uniform, apex rounded.

Habits. These mites were generally believed by early workers to feed upon stored grain and their true nature as parasites of grain-infesting insects was not suggested until 1883 (by Webster). The following information is taken largely from Herfs (1926), and Krczal (1959b), and deals with *P. herfsi* and *P. scolyti* respectively. All known members of the genus are external parasites of insects, usually killing the host species. Hosts are recorded from the following orders: Homoptera, Coleoptera, Lepidoptera, Diptera, and Hymenoptera. In nearly all cases, the hosts are attacked in their immature stages, but there are occasional records of the parasitization of adults [*Callidium variable* (Cerambycidae), *vide* Brucker (1901); *Isosoma* (= *Harmolita*) *tritici* (Fitch) (*Eurytomidae*), *vide* Webster (1910); *Tineola biselliella* Hummel (Tineidae), *vide* Herfs (1926)] and of eggs [*Magicicada septendecim* L. (Cicadidae), *vide* Marlatt (1898); and *Fidia viticida* Walsh (Chrysomelidae) according to Webster (see Reuter, 1900)]. Certain larvae may be immune to attack. Herfs mentions that the mites in his cultures failed to successfully parasitize larvae of *Ephestia kuhniella* Zeller although they readily attacked and killed those of *Tineola biselliella* and *Pectinophora* (= *Gelechia*) *gossypiella* (Saunders). A larval cerambycid and the larvae of "Ringelspinner" were likewise not parasitized. Herfs concludes that this immunity exists by reason of the depth or hardness of the cuticle. Still other larvae, *e. g.*, those of *Diloba caerulocephala,* were attacked and killed without enabling the parasite to complete its development.

Both males and females pass through all immature stages while still within the enormously distended, globular opisthosoma of the mother mite, and are born as adults. Most males are born during the first half of the birth period and normally are present only in small numbers (three to five percent of the total number of offspring at 25° C.). They seldom leave the body of the mother and

are parasitic upon it. At 25° C., males of *herfsi* removed from the maternal "opisthosomal globe" died 16 to 25 hours after removal, presumably from starvation, and if placed on the bodies of normal, healthy hosts did not feed. Males are usually found resting quietly on the opisthosoma of the mother, for the most part near the vulva, or (*P. scolyti*) the first born male may remain partially within the vagina of the mother, only the posterior portion of its body protruding through the vulva. They may (*herfsi*) or do not (*scolyti*) assist in the birth of the females by grasping the latter with the hind legs and pulling, shifting the grasp, pulling again, etc. This aid is not necessary since birth of the females continues smoothly in the absence of males although taking slightly longer (average birth time of females of *herfsi* with males, 171 seconds, average time without males, 217 seconds). In *scolyti* the combined processes of birth and mating require less than a minute.

As soon as (*herfsi*) or shortly before (*scolyti*) the newly born female completely leaves the birth canal, the male initiates copulation. In *herfsi,* he grasps the female and adjusts, with the assistance of the hind legs, her body until contact is made. This entire process of adjustment and mating may take 10 minutes or more, although actual copulation probably lasts only 20 to 30 seconds. Females of *scolyti* push past the intruded body of the male until they reach the level of the hind legs, at which point they are grasped and mated. Brucker (1901) observed copulation to take place on the host rather than on the opisthosoma of the mother. This may be a specific difference, since the material investigated by Brucker parasitized *Callidium* sp. (*Curculionidae*) while Herfs' forms were found on lepidopterous larvae. Because of the configuration and length of the hind legs in the male, Oudemans (1936) designates this first form *P. bruckeri, nom. nov.*

Males of *herfsi* normally assist only in the birth of the females, paying no attention to emerging males. They likewise ignore mated females, although one or more males may attempt to disrupt pairs *in copulo.* Early in the birth period of the mother, only a single *herfsi* male is usually found on the opisthosoma but as this period progresses, several may be present. The second and succeeding males of *scolyti* likewise take up parasitic residence upon the maternal hysterosoma. They seemingly function as replacements for the male situated partially within the vagina, and wait to assume its task of inseminating each female as she is born.

Shortly (within 10 minutes) after being mated, the young female leaves the body of the mother and seeks food. If, however, males

are lacking on the maternal hysterosoma, young females do not leave but remain resting upon the latter for some time awaiting the birth of a male. Only after a full day or longer do they leave. Unmated females seemingly suffer a high mortality, only about 10 percent of those in experimental cultures surviving to produce offspring. Such females are arrhenotokous, producing only males. The total number of offspring produced compares favorably with that of mated females of the same size.

According to both Krczal and Herfs, young females die of starvation within 48 hours of their birth if food is not found. This statement makes dispersion and perhaps overwintering difficult to explain since it is obviously the young females which must disperse. Herfs found that young females unable to find a host would sometimes return to the mother and feed in the manner of the male on the parent's hysterosoma. Rarely this filial parasitism became permanent and ended with the death of the mother and the production of offspring by the daughter. More commonly it was quite transitory and resulted in no visible harm to the mother while seemingly providing the daughter with enough food to prevent at least immediate starvation.

Young females of both *herfsi* and *scolyti* are stimulated by moving objects soon after leaving the mother, stretching the body toward the source of the stimulus. Such behavior indicates dispersion by phoresy, a phenomenon which has been observed only rarely in *Pyemotes* despite its widespread occurrence in other members of the family. Krczal observed young females of *scolyti* attached to adult *Scolytus scolytus* to live somewhat longer than isolated females of the same age, from which he concluded that such phoretic females fed from body exudates of the host without obtaining enough nourishment to initiate physogastry.

In view of the fact that young females starve so quickly, the questions of their survival between generations of the host and of overwintering remain essentially unanswered. As mentioned by Krczal, perhaps the phoretic period is ephemeral, serving only to bring the females into fortuitous contact with one of a number of possible hosts. This could explain their rare and sporadic occurrence in the nests of solitary bees and social wasps, hosts in which an overwintering period would be required of the young females. Presumably, such a period would result in their migration or death, thus preserving the host from further attack until the next "accidental" infestation occurred.

Upon finding a host, the young female selects a favorable location and inserts her chelicerae, an action which may elicit striking or curling movements from the host. Within a short time, the host begins to show signs of paralysis, this increasing until the larva is completely incapable of movement. Time elapsed between onset of attack and complete paralysis depends upon the number of punctures made, but generally is two to four hours. The same larva may be attacked by several mites, Herfs having counted a maximum of 178 on a single host.

The parasite develops quickly, the opisthosoma increasing in both length and width until the mite assumes a form (the "Zitronenstadium" of Herfs) quite similar to an incandescent light bulb. This stage is usually reached in about 24 hours. Complete development, in which the opisthosoma becomes a huge, turgid sphere may be completed in another 24 hours, although it usually requires seven to eleven days to reach maximum size. At 25° C. the average time from initial insertion of the chelicerae to birth of the first offspring is 9.5 days in *P. herfsi.*

The size of the opisthosomal globe is well correlated with the number of offspring produced. In cases of multiple parasitism the size of the opisthosoma will be reduced, and females concerned will produce a relatively small number of offspring, sometimes averaging as low as six or seven. Females of *herfsi* reared singly produced a maximum of 284 offspring and averaged 128 at 25° C. and 150 "at room temperature." The birth period, usually terminated by the death of the female, ranged from 9 to 33 days and averaged 17.3 days. The average life span of the females in Herfs' cultures at 25° C. was 26.8 days as measured from the beginning of feeding to the death of the mite.

The average life span of the male is much shorter, since it dies with the mother mite. It was found that longevity of *herfsi* males was also positively correlated with amount of sexual activity. The temperature of the microhabitat was also an important factor affecting both longevity and fecundity of both sexes. Several previous workers have found 25 to 30° C. to be optimum and Herfs noted a loss in the ability of the mother to give birth at 35° C.

DISTRIBUTION. At least *P. ventricosus,* cosmopolitan.

SPECIMENS EXAMINED. At least two species (one near *scolyti,* one near *boylei*) from many parts of the United States from the following hosts or situations: scolytid beetle, nest of wasp, man, cotton crop residue, pink bollworm larvae, scale (*?Chrysomphalis*) on *Quercus macrocarpa Michx.*

Species thought to belong in *Pyemotes:*

alastoris (Froggatt, 1894) (*Heteropus*) *Nomen dubium*
anobii Krczal, 1959
attelabrinus (Debey, 1849) (*Dermaleichus*)
beckeri Krczal, 1959
boylei Krczal, 1959
bruckeri Oudemans, 1937
dryas (Vitzthum, 1923) (*Pediculoides*)
Eccoptogasteri pruni Amerling, 1862 (*Piemotes*) *Nomen nudum*
fortuitus (Oudemans, 1936) (*Pediculoides*)
hartigi Oudemans, 1937 *Nomen dubium*
herfsi (Oudemans, 1936) (*Pediculoides*)
heterogyne (DeFilippi, 1862) (*Lais*)
larvarum (Lichtenstein, 1868) (*Physogaster*) *Nomen nudum*
megnini (Oudemans, 1936) (*Phthiroides*)
monunguiculosus (Geber, 1879) (*Chrithoptes*)
schwerdtfegeri Krczal, 1959
scolyti (Oudemans, 1936) (*Pediculoides*)
takeuchii (Sasa, 1947) (*Pediculoides*)
tritici (LaGreze-Fossot and Montané, 1851) (*Acarus*)
ventricosus (Newport, 1850) (*Heteropus*)

Siteroptes Amerling

As defined herein, this genus includes several forms placed by various authors in *Pygmephorus* and other genera. Although including a series of forms which range from a relatively primitive *Dolichocybe*-like species to forms very closely related and ancestral to the mites of the subfamily Pygmephorinae, the author has preferred to include them in a single genus divided into three subgenera. In addition to these, the author has seen a single damaged specimen of an undescribed species which is obviously quite closely related to primitive forms of *Pediculaster,* and which, when described, should undoubtedly form a fourth subgenus.

A relatively large number of forms seemingly occur in North America. Fifteen species are thought to be included in the material, nearly entirely North American, studied during the course of this work.

Most species are thought to be phytophagous or saprophagous. Only *S. aradii* Krczal is known to be phoretic upon insects.

DIAGNOSIS. The females of this genus may be distinguished from those of all other genera in the family by the following combination of characters: leg I with five segments; single claw of tarsus I simple, pedicellate, lacking thumb; chelicerae small, indistinct; palps free.

DESCRIPTION OF NON-GRAVID FEMALE. Length, approximately 155 to 390μ; width, approximately 75 to 175μ; hysterosoma elongate-cylindrical to broadly elliptical; body usually weakly, occasionally moderately sclerotized, and without coarse punctae.

Gnathosoma. Squarish to elliptical, normally directed anteriorly; palp distinct, free, short to moderate in length, its apex usually dentate, one tooth usually much longer than the rest; chelicera tiny, indistinct; esophageal-pharyngeal pump absent; esophagus straight, thick, usually indistinct.

Propodosoma. Dorsum. Soft, shape variable according to mount but generally elongate-trapezoidal or elongate with sides broadly sinuate, expanding laterally at points of articulation of legs I and II, anterior margin forming cervix which encloses base of gnathosoma, this cervix continuing around gnathosoma to form indistinct foraminal collar which may or may not become excavated on ventral surface; posterior margin meeting or barely covered by first hysterosomal segment; pseudostigmata present, arising in posterior one-half; three pairs of propodosomal setae, posterior pseudostigmatals always distinctly longer than other two pairs; peritremes dorsal and anterior, or arising anteromesally near stigmatal setae, elongate-cylindrical to guttate or (rarely) circular; esophageal "finned" structures present, indistinct or distinct, usually one short structure in gnathosoma or propodosoma followed by a more or less globular or quadrate structure, this followed by a third structure which may be similar to the preceding one or by a shorter structure whose posterior margin is distinctly defined and recurved cephalad. *Venter.* Anterior ventral plate with four (rarely) to six pairs setae, ventrites I usually with three pairs; external ventrals I forked or not; coxa I attached at a right angle to longitudinal axis of body; apodemes II distinct, weakly sigmoid, usually incomplete medially, always bending posteriorly as they approach anterior median apodeme; anterior median apodeme distinct, complete, posterior marginal apodemes well developed only laterally; large band of pleated conjunctiva indistinct or absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment entire, meeting or extending slightly over posterior margin of propodosomal dorsum; third and fourth segments with one or two pairs setae; fifth segment usually overlapped by fourth segment, enclosing apex of hysterosoma, bearing three pairs of setae; vulva apical, usually distinct, vagina enclosed apically by sclerotized, U-shaped, globose to elliptical

pumplike enlargement or vaginal wall merely sclerotized apically; anterior and median genital sclerites absent; posterior genital sclerites usually also absent; a globose or omega-shaped vaginal structure sometimes distinct. *Venter.* Posterior ventral plate poorly defined anteriorly, entire or divided behind coxae III into two parts (fig. 19), the margins of these parts not corresponding to the ventral apodemes (epimera of authors), which are separately distinct; posterior ventral plate with four (rarely) to six pairs of setae, hind margin of posterior ventral plate trilobed, with single median lobe, or entire; external presternals well posterior to and directly behind or only slightly laterad of internal presternals; external poststernals rarely absent, if present distance behind coxae IV variable; apodemes III variable, present only laterally or complete, joining posterior median apodeme with anterior sternocoxal condyle of III; apodemes IV variable, distinct only laterally, or complete or nearly so, always joining anterior sternocoxal condyles of legs IV; apodemes V present or absent; posterior median apodeme variable, distinct only in region of apodemes IV, or well developed; opisthosoma (dorsally between terga III and IV, ventrally between the opisthosomal venter and segment V) with or without a wide band of distinctly pleated conjunctiva; opisthosomal venter entire, devoid of setae except in some *Metasiteroptes.*

Legs. Variable in length and thickness; leg I at least slightly thicker than leg II, five segmented; tarsus I quadrate, rectangulate, or elliptical, never wider than femurogenu I; lateral sensory spot absent; claw I single, simple, hooklike, moderately developed, distinctly pedicellate, pedicel stalklike, short, but usually distinctly longer than wide; thumb absent; trochanter I with three (rarely) or four setae, seta *c* long, setiform; trochanter II with three setae, femurogenu II with one to three; trochanter III with one or two setae, femurogenu III with one or two; tarsi II and III each with six (rarely) or seven tactiles; solenidium of tarsus II in proximal half; sensory pegs of tibiae II and III present; claws II to IV simple, subequal in size; pulvilli II to IV variable; coxa III elongate-triangular to elongate subcordate in inner ventral aspect; coxa IV triangular and smaller than coxa III (*Metasiteroptes*), quadrate, or short-rectangulate, usually widest at base; femurogenu IV with one seta or none; tarsus IV usually short and abruptly constricted basad of pretarsus; ratio of femurogenu IV to tarsus IV 1:2.1 to 1:6.2 (only rarely over 3.8—if as large as 6.2 then mite very large, 385μ long and having trochanter I with only three setae).

DESCRIPTION OF GRAVID FEMALE. Gnathosoma and propodosoma as described for non-gravid female, but entire hysterosoma becoming physogastric, globular. Diameter of hysterosoma of females as great as three millimeters.

DESCRIPTION OF MALE (based on three species of *Siteroptes s. str.* and *Siteroptoides*). Length, 120 to 165μ; width, 70 to 95μ; hysterosoma generally ovate, sharply constricted in vicinity of legs IV, opisthosoma forming enlarged connate, globose, or subtriangular copulatory structure; conjunctival areas not granulose.

Gnathosoma. Vestigal, present only as reduced lobe of varying shapes, this lobe bearing one median dorsal pair, one anterodorsal pair, and one posteroventral pair of tactile setae, in addition to two anteroventral pairs of solenidia.

Propodosoma. Dorsum. Much broader than that of female, bearing four pairs of setae. *Venter.* Similar to that of female but shorter and broader; with either five or six pairs of ventral setae.

Hysterosoma. Dorsum. Segmentation modified, first plate large, usually rounded posteriorly, bearing three pairs of setae; second plate much smaller, strongly or weakly defined, variable in shape, bearing one or two pairs of setae; third plate forming basal portion of genital capsule, with two pairs of setae, both pairs usually sensory, the anterior pair much the larger; aedeagal capsule large, attenuate apically, bearing two pairs of apicoventral setae; aedeagal armature well sclerotized, divided longitudinally into halves, pointed apically, short, aedeagal base not greatly elongate, not plainly recurved; internal "vesicula seminalis" usually globular, possessing lateral "wings." *Venter.* Apodemes IV and V well developed, apodemes III strongly developed entirely or only laterally; posterior median apodeme present, connecting apodemes V with apodemes IV or often ending anteriorly to join apodemes III; anterior extremities of apodemes V joining posterior median apodeme, characteristically obfurcate between coxae IV; setation of posterior ventral plate as described for female; hind margin of posterior ventral plate well posterior to coxae IV, enclosing genital capsule; opisthosomal venter apparently fused with genital capsule, not distinct.

Legs. All legs five-segmented; length, claws, setation, and proportions of legs I-III similar to those of female; leg IV tonglike, modified for clasping, short; coxa IV subquadrate, trochanter IV not distinctly arcuate, tarsus IV greatly reduced, two claws present but at least one greatly deformed, scooplike or irregular.

Key to the Subgenera of *Siteroptes* (Females)

1(*a*). Coxa IV triangular; posterior ventral plate divided and appearing as two distinct plates, each bearing a pair of legs
Metasiteroptes, new subgenus, p. 105

1(*b*). Coxa IV quadrate or rectangulate; posterior ventral plate entire....2

2(*a*). Peritremes guttate, circular or rarely elongate-guttate, usually not much longer than wide, separated by less than one of their lengths; femurogenu II with three setae; apodemes V always well developed; ventrites II each with two or three setae
Siteroptoides, new subgenus, p. 113

2(*b*). Peritremes usually elongate, at least twice as long as wide, or if circular or short-guttate, then separated by at least one of their own lengths; femurogenu II with two or three setae; apodemes V rarely well developed; ventrites II each with two setae...*Siteroptes sensu stricto*, p. 108

Metasiteroptes, new subgenus

(Figs. 19-20)

Type, *Siteroptes* (*Metasiteroptes*) *macer*, new species.

This subgenus is established to accommodate two species which retain several of the more primitive characters found in *Dolichocybe*, *etc.* including short, oblique, incomplete apodemes III, and triangular coxae IV. They are easily distinguished from all other known species of *Siteroptes* and perhaps deserve generic status.

DIAGNOSIS. For females, see the key characters. Males and immatures are unknown.

DESCRIPTION OF NON-GRAVID FEMALE (based upon S. *macer*). Hysterosoma elongate-cylindrical; body weakly sclerotized.

Propodosoma. Dorsum. Peritremes guttate, separated by much less than one of their lengths, only slightly diverging anteriorly; esophageal "finned" structures indistinct. *Venter.* Anterior ventral plate with five pairs of setae, ventrites II with two pairs; external ventrals I not forked.

Hysterosoma. Dorsum. First segment meeting posterior margin of propodosoma, fourth tergum with but a single pair of setae. *Venter.* Posterior ventral plate bipartite, divided transversely between hind margins of third coxae, each plate thus bearing one pair of legs; posterior ventral plate with five pairs of setae, one pair of poststernals lacking; posterior margin of posterior ventral plate with median lobe; apodemes III distinct only laterally; apodemes IV arcuate, weak but complete, arising laterally from anterior sternocoxal condyles of coxae IV; apodemes V absent; posterior median apodeme present only on hind portion of posterior ventral plate, its anterior extremity meeting apodemes IV; extent

of pleated conjunctival bands not ascertainable because specimens are gravid.

Legs. Short; leg I much thicker than leg II; tarsus I quadrate-tapering; trochanter I with four setae; femurogenu II with one seta, femurogenu III with one; tarsi II and III each with six tactiles; solenidium of tarsus II near basal margin; pulvilli II to IV flaplike, longer than claws; claws II to IV stout; coxa III elongate-triangular in inner ventral aspect; coxa IV triangular, shorter than coxa III; femurogenu IV with one seta; tarsus IV resembling tarsus III in size and shape; ratio of femurogenu IV to tarsus IV approximately 1:2.7.

DESCRIPTION OF GRAVID FEMALE. As described above except that body becomes physogastric. Although the type females of S. *macer* are gravid, it is difficult to ascertain whether physogastry involves the entire hysterosoma or whether it is of the type found in *Pyemotes* in which only the opisthosoma becomes enlarged.

HABITS. Since gravid females were taken from the stems of sugarcane, it is possible that these mites are fungivorous in the manner of *Siteroptes sensu stricto.* Sporelike artifacts were found clinging to the bodies of both specimens of S. *macer.* The specimens of *aradii,* found upon the bodies of *Aradus depressus,* are the only forms known in the genus to practice phoresy.

Species thought to belong in *Metasiteroptes:*

?*aradii* (Krczal, 1959) (*Pyemotes*)
macer, n. sp.

Siteroptes (*Metasiteroptes*) *macer,* new species

DIAGNOSIS. Separable from *aradii* (Krczal) in being more slender, in the size and location of the dorsal setae of all segments, in the setation (and character?) of the posterior ventral plate, and in various other characters.

DESCRIPTION OF GRAVID FEMALE. (Only gravid females are known.) Distance between anterior sternocoxal condyles of coxae III, 43μ (44).

Gnathosoma. Elliptical, length, 20μ; width, 16μ; external dorsals absent; solenidia I indistinct, solenidia II elongate, weakly clavate; first palpal setae well anterior.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets 25μ (24); peritremes guttate, only slightly divergent, 0.4μ (0.4) apart; propodosomal setae stout, aciculate, indistinctly

spiculate; stigmatal setae about one and one-quarter times as long as, anterior pseudostigmatals subequal to, and posterior pseudostigmatals about two and one-quarter times as long as pseudostigmata. *Venter.* All setae aciculate, nude, short, all those of ventrites I and internal ventrals II approximately 7-10μ; extenral ventrals II about 15μ long, distinctly behind internal sternals II and closer to coxa II than to them.

Hysterosoma. Dorsum. All dorsal setae aciculate, indistinctly spiculate; dorsals I stout, 40μ long (44), well posterior to laterals I, latter about 42μ (37) long, arising from posterior one-fifth of segment; dorsals II as stout and long as laterals I, arising directly posterior to dorsals I; dorsals III barely median of dorsals II and as stout and long, laterals III above and laterad of these, arising from middle of the segment, approximately 14μ long; dorsals IV directly behind dorsals I and II, about as stout and long as former, laterals IV absent; segment V with only two pairs of apicoventral setae, external pair as stout as setae of IV but shorter, about 29μ (31), internal pair about three-fifths of distance between external pair and longitudinal median line, short, 4μ (6). *Venter.* Posterior ventral plate elongate, distance from its anterior margin to anterior condyles of coxae III greater than length of coxae III; posterior margin of coxae III separated by approximately 10μ from anterior margin of coxae IV; posterior ventral plate divided into a posterior and an anterior portion separated by conjunctival area, each portion bearing a pair of legs; hind margin of anterior portion rounded, meeting anterior inner margins of coxae III laterally, this portion bearing internal and external presternals and first axillary setae as well as apodemes III; hind margin of posterior portion of plate with median lobe, this portion bearing one pair of poststernals, the second axillary setae, and apodemes IV; apodemes III developed only laterally, longitudinal median suture lacking between them, apodemes IV joining medially, forming a broadly inverted U, their point of fusion marking anterior extent of median longitudinal suture which extends posteriorly to posterior margins of coxae IV; first and second axillaries arising from their respective apodemes; one pair of poststernals, these approximately 3μ behind posterior margins of coxae IV, about as close together as internal presternals; all ventral setae short, smooth and aciculate, either about 0.25 or 0.70 times length of pseudostigmata.

Legs (all measurements in μ). *Length.* Leg I, 56; Leg II, 51; leg III, 55 (59); leg IV, 62 (63). *Width.* Leg I, 12 (13); leg II, 10 (11); leg III, 10 (10); leg IV, 9 (11). *Segment lengths.* tr I, 22 (24); ti I, 13; ta I, 12; ta II, 17; ti III, 9 (11); cx IV, 24; tr IV, 24 (23); fege IV, 8 (7); ta IV, 19 (20). *Setation.* Leg I: cx 1T, tr 4T, fege 3T, ti 6T + 2S, ta 6T + 7S; leg II: cx 1T, tr 3T, fege 1T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T, ta 6T.

Tarsus I distinctly thinner than tibia I; solenidium 1 of tibia I stoutly pedicellate, 6.5μ long; solenidium of tarsus II small (0.3μ), clavate; coxa III long-triangular, length 24μ (26), width 1μ (1), coxa IV also triangular, shorter, length 21μ, width 1μ (1).

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Holotype and one paratype, both gravid females, Barbados, British West Indies (intercepted in quarantine at New York, April 2, 1939, Post, collector), on stem of sugarcane, U. S. National Museum Lot Number 39-5651.

TYPE REPOSITORIES. Holotype and one paratype in the U. S. National Museum.

Subgenus *Siteroptes, sensu stricto*

(Figs. 10-12, 25-28)

Siteroptes Amerling, 1861, Lotos, XI: 26, *sine typo.* Type, *Siteroptes cerealium* Kirchner, 1864, Lotos, XIV:126, by subsequent designation, Kirchner, 1864.

Thermismoptes Amerling, 1861, Lotos, XI: 26, *sine typo.* Type, *T. cerealium,* Kirchner, 1864, Lotos, XIV: 125, by subsequent designation, Kirchner, 1864.

Pediculopsis Reuter, 1907, Festschrift für Palmen, 7: 3, Helsingfors. Type, *Pediculoides graminum* Reuter, 1900, by original designation.

Type: *Siteroptes cerealium* Kirchner, 1864, by subsequent designation, Kirchner, 1864.

This genus contained only the species *cerealium* Kirchner, 1864 (= *P. graminum* Reuter, 1900) until 1957, at which time Krantz described S. *reniformis.* The author has at least five additional undescribed species. Members of this subgenus are considered to be more specialized than those of *Metasiteroptes* in that coxa IV differs in shape from coxa III and the posterior ventral plate is entire. Many members of the group have lost at least one pair of setae on the posterior ventral plate, a loss often correlated with the loss of the third laterals. Apodemes III are usually distinct only laterally and are incomplete, apodemes IV are weak, incomplete or complete but always present near the midline. Apodemes V are only rarely present. Ventrites II always bear two pairs of setae.

The peritremes are only rarely guttate and if so, then are widely spaced; they usually diverge less than 90 degrees. Members of this subgenus are considered to be less specialized than those of the following subgenus although intergrades between the two groups occur.

DESCRIPTION OF NON-GRAVID FEMALE. Agrees with the description of the genus except for the following: length, 160 to 265μ; width, 75 to 130μ.

Propodosoma. Dorsum. Peritremes usually large, elongate-guttate or elongate-cylindrical, or if rarely circular or short-guttate then separated by at least one (usually more) of their own lengths, their axes usually not diverging more than 90 degrees. *Venter.* Anterior ventral plate with five pairs of setae; ventrites II always with two pairs.

Hysterosoma. Third tergum often with only a single pair of setae, the laterals absent. *Venter.* Posterior ventral plate entire; apodemes III incomplete medially, usually not extending mesally beyond internal presternals; apodemes IV weak, complete or incomplete, always distinct along midline and laterally in front of coxae IV; apodemes V usually absent; posterior median apodeme weak or absent anterior to its union with apodemes IV.

Legs. Trochanter I with four setae; femurogenu II with one to three (usually two) setae; tarsi II and III each with seven tactiles.

Species thought to belong in *Siteroptes s. str.:*

antiquissimus (Krczal, 1959) (*Pygmephorus*)
avenae (Müller, 1905) (*Pediculoides*)
cerealium Kirchner, 1864
dianthophilus (Wolcott, 1908) (*Pediculoides*)
graminum (Reuter, 1900) (*Pediculoides*)
primitivus (Krczal, 1959) (*Pygmephorus*)
reniformis Krantz, 1957

HABITS. *Siteroptes cerealium* [4] is important as a principal vector of *Fusarium poae* (Peck) (Deuteromycetes), the pathogen of a disease variously known on a number of meadow grasses as "silvertop," Weissährigkeit, or Bollnäserkrankheit, and on carnations as "central bud rot" (Cooper, 1940). In addition, it has recently (Alfaro, 1946) been implicated in the transmission of *Nigrospora oryzae* (Berk. & Br.), a fungal parasite of grains.

4. A discrepancy in the number of chromosomes found by Reuter (1909b) and Cooper (1937) was found to exist. Cooper (1939) states, after examination of some of Reuter's slides, that the latter author was in error, the correct diploid chromosome number being six.

The most important works dealing with the bionomics, genetics, morphology, and embryology of this species are those of Alfaro (1946), Bradbury (1926), Cooper (1937, 1939, 1940), Molz and Morgenthaler (1912), Reuter (1900, 1907, 1909), Stewart and Hodgkiss (1908), Weiss (1915), and Wolcott (1908).

The following account of the life history of *S. cerealium* is taken largely from Reuter (1900 and 1909a), and Cooper (1937, 1940).

Apparently, only the young mated females of this species disperse. These females readily leave their place of birth and seek food and shelter. They are capable of traversing tight places and are able to escape from and enter vials tightly stoppered with cotton plugs. Those attacking grasses commonly take up residence between an upper (usually the uppermost) leaf sheath and the culm; those attacking carnations force their way into the buds where they are found near the inner floral organs. Once so located, the young female begins to feed, this feeding being prerequisite to physogastry. The exact nature of the food is not known. All authors agree that tissue necrotized through the invasion of *F. poae* is ingested. Alfaro (1946) and Reuter (1900) state, in addition, that the mites are capable of attaining physogastry after feeding upon healthy tissue. Cooper (1940) doubts this to be the case, finding physogastric females to be associated only with diseased plants in every instance. The same author found that the mites will feed and readily subsist upon the mycelium of *F. poae* isolated in agar plates.

The duration of the feeding period before the onset of physogastry is not clear but Cooper (1940) mentions one case in which noticeable swelling occurred six days after the females were placed on the soil near carnations in a greenhouse. How much, if any, of this period was spent in waiting for the plant tissue to become suitably decomposed by the fungus is unknown.

Females become increasingly less mobile as physogastry progresses and finally become totally incapable of movement, remaining anchored by palps and (probably) by at least one pair of front legs until they die. The volume of these females may be increased to 100 to 500 times that of non-gravid forms, and their width may measure 3000μ. Like those of many other genera and unlike those of *Pygmotes*, the entire hysterosoma swells, balloonlike, while the propodosoma remains unmodified. Within this fluid-filled hysterosomal globe, the eggs develop and hatch into active hexapod larvae. In most instances, these remain within the maternal body, where

they supposedly quickly molt to the octapod nymph. According to Reuter (1900), these latter are distinguishable as to sex and differ from the adult only in the development of the organs of reproduction. The appearance of this stage is an anomaly seemingly restricted to members of this genus, or perhaps to *cerealium*. I have seen males and larvae of several species but no nymphs. Perhaps later research will prove Reuter's nymphs to have been merely teneral adults. The species differs from previously discussed members of the Pyemotinae and from known Acarophenacinae and resembles most Pygmephorinae in having at least one definitive immature stage.

According to Reuter, larvae and nymphs (especially the latter) are often born and move freely about the host plants where they soon settle and molt to the ensuing stages. Cooper (1937) states that this is rarely the case and that usually only adult mites are born.

The above author gives the time of development from egg to nymph as four to five weeks but makes no mention of the temperatures at which this rate of development occurred. Both he and Alfaro state that two or three generations occur in a season.

Although Reuter thought that mating takes place on the host plant, Cooper (1937) found that laboratory-reared mites usually mate in the adult stage while still within the body of the mother but noted that in rare instances mating took place while adults were still upon the surface of the maternal hysterosoma. Copulation was observed to last between 5 and 35 seconds.

The mass birth of the offspring is attended by the hysterosomal breakdown and accompanying death of the mother.

Cooper (1937) counted the offspring obtained from three series of females. The first series contained 17 female parents and totalled 1643 offspring (mean, 96.5/female), the second 72 females and 11,446 offspring (mean, 158.8 offspring/female), and the third 30 females and 4385 offspring (mean, 146.0/female). No information as to the circumstances surrounding the procurement of these three samples or reasons for the large differences in mean fecundity between them are given. The same author found males to occur in every brood, although in small numbers. The three samples mentioned above produced 4.50, 4.46, and 5.15 percent males respectively. Reuter (1900) found no males in the spring but a progressive increase in their numbers during the summer until a high of about 13 percent males was reached in the fall. This increase was thought to coincide with the need for relatively large numbers of

mated overwintering female nymphs and the absence of males in the spring was attributed to the fact that they do not overwinter. On the basis of the findings made in related genera, it is most probable that a relatively constant number of males is produced in every generation, as inferred by Cooper. Similar evidence suggests that mated females, rather than nymphs, are the overwintering forms.

The above two authors concur in recording high mortality invariably occurring in unmated females. Cooper noted only two cases in which such females became physogastric. Both were arrhenotokous. It is interesting to note that the mean number of offspring per female (306) in these two cases was considerably higher than in mated females. Perhaps this discrepancy may be explained by the relatively smaller size of the male.

Gravid females may be found in gradually increasing numbers until October. These produce large numbers of forms which (see above) Reuter believed to be overwintering female nymphs. According to that author, such nymphs may be virgin or may be mated immediately after birth. The former usually die the ensuing spring without molting to adulthood.

Cooper (1940) has demonstrated the ability of S. *cerealium* to transmit the spores of *F. poae* to carnation, and Alfaro (1946) has experimentally transmitted the fungus *Nigrospora oryzae* by means of the same mite. The present author has sometimes seen elliptical or circular sporelike objects upon or within the bodies of *Siteroptes* females.

The relationship between the fungus and the mite is stated to be a symbiosis in which the mite disseminates and innoculates the fungus which alters the plant tissue to provide (more suitable) food for the mite. Cooper points out that this symbiosis is antagonistic in that the mite may feed upon the fungus.

The phenomenon investigated and named *Karyomerokinesis* by Reuter (1909b) is reinvestigated in detail by Cooper (1939). Aside from a unique elaboration of Feulgen-negative chromosomelike material between separating chromosomes, mitosis in the early cleavage divisions of the egg is similar to that found by Pätau (1936) for *Pyemotes ventricosus*. Karyomery and the formation of equatorial bodies ceases by the tenth cleavage division. Karyomeres disappear in the prophase, reappearing as vesicles in the telophase. *Specimens examined.* Nine species, including *reniformis* and prob-

ably *cerealium* and *primitivus*, from many parts of the United States and from France, from the following situations or hosts: Salt marsh grass (*Distichlis* sp.), grass, *Celtis occidentalis* L., carnations, cotton bolls (syntypes of *reniformis*), milo maize, *Setaria* sp., nest of *Microtus* sp., treehole in *Fagus grandifolia* Ehrh., peach orchard soil, decaying log, forest floor litter.

Siteroptoides, new subgenus

(Figs. 51-53)

Type, *Siteroptes* (*Siteroptoides*) *absidatus*, new species.

This new subgenus contains at least six species. Although its forms intergrade with those of *Siteroptes s. str.*, it is considered to be more specialized than the latter and perhaps more closely related to *Pediculaster* and the Pygmephorinae, as evidenced by the development of the apodemes of the posterior ventral plate, by the location, proximity, and amount of divergence of the peritremes, and by the additional pair of setae of the second ventrites.

Description of Non-gravid Female. Length, 150 to 320μ width, 80 to 160μ; hysterosoma elliptical.

Propodosoma. Dorsum. Peritremes guttate or elongate-guttate, occasionally septate, usually diverging at least ninety degrees, separated at their bases by less than one of their widths. *Venter.* Anterior ventral plate with five (rarely) or six pairs of setae, when six then ventrites II with three pairs.

Hysterosoma. Dorsum. Third and fourth terga usually with two pairs of setae, laterals rarely reduced or absent. *Venter.* Posterior ventral plate entire, usually bearing six pairs of setae, or (rarely) internal poststernals absent; external poststernals always well behind posterior margin of coxae IV; apodemes III always well developed, complete or nearly so, bending posteriorly at the sides to join anterior sternocoxal articulation of III, bending posteriorly in the middle to join posterior median apodeme; apodemes IV complete (sometimes distinctly weakened near posterior median apodeme), usually indistinctly forked laterally, one branch bending posteriorly to join anterior sternocoxal articulation IV, the second branch meeting and continuing posteriorly and dorsally around the margin of coxal foramen III; apodemes V well developed, joining the posterior extremity of the posterior median apodeme; posterior median apodeme always well developed anterior to apodemes IV, meeting apodemes III.

Legs. Trochanter I with four setae; femurogenu II always with three tactiles; tarsi II and III each with seven tactiles.

Species thought to belong in *Siteroptes* (*Siteroptoides*):

absidatus, n. sp.
priscus (Krczal, 1959) (*Pygmephorus*)

HABITS. Nothing is known of the habits of this group. Those in the author's collection were collected in a variety of habitats—on plants, in soil, in a treehole, and in cattle manure in a rearing cage of *Siphona irritans*. One specimen (from Soledad, Cuba) has a single sporelike structure attached to it.

SPECIMENS EXAMINED. In addition to the type series of *absidatus* probably six species from many parts of the United States and from Cuba, Haiti, and Holland, from the following situations or hosts: treehole in *Fagus grandifolia*, stems of *Paeonia* sp., corm of *Gladiolus* sp., oats, and on cattle droppings in cage of *Siphona irritans* L. (Diptera).

The specific status of some of the specimens is not clear. Including *absidatus*, the author has three forms which are closely related and which may be conspecific, differing in size, shape, and location of the solenidia of tibia and tarsus I as well as in minor features of the placement and size of the setae of terga III, IV, and V. In view of the small number of specimens at hand, obviating any possibility of ascertaining intergradation, if present, it has been considered best to restrict the definition of *absidatus* to the three specimens described.

Siteroptes (*Siteroptoides*) *absidatus*, new species

DIAGNOSIS. Differs from *priscus* (Krczal) in the shape of solenidia 3 and 4 of tarsus I, in that the peritremes are more widely spaced, in that external caudals II are much longer than the other two pairs, and in various other characteristics.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 265μ (150-265); width, 132μ (80-132); distance between anterior sternocoxal condyles of coxae III, 74μ (55-74).

Gnathosoma. Quadrate, approximately 30 x 30μ; external dorsals arising well laterad of and slightly behind internal dorsals, aciculate; solenidia I distinct, appearing concave apically, solenidia II elongate, clavate; distance between first and second palpal setae about 7μ; esophagus with small, slightly thickened mesal dilation.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets 29μ (22-30); peritremes guttate, greatly divergent,

their long axes making an angle of about 130 degrees, their most mesal margins 4μ (2-4) apart; propodosomal setae stout, aciculate, spiculate, the stigmatals 29μ (17-29), the anterior pseudostigmatals only slightly shorter, the posterior pseudostigmatals comparatively short, 40μ (29-42), arising slightly behind internal pseudostigmatal sockets and on longitudinal line drawn through their mesal margins. *Venter.* Six pairs setae, ventrites I and II each with three pairs; setae of anterior ventral plate aciculate, nude, short, range 11 to 20μ, median ventrals I closer to anterior median apodeme than median ventrals II, external ventrals I not forked, arising posterior to internal ventrals I; ventrals II subequally spaced and sublinearly arranged.

Hysterosoma. Dorsum. All dorsal setae stout, aciculate, sparsely spiculate; setae of segment I in a transverse row, dorsals I 29μ (18-30), 40μ (30-42) apart, laterals I 41μ (26-45), distinctly closer to respective dorsals than dorsals to each other; dorsals II 34μ (24-39) long, 50μ (39-53) apart; dorsals III as laterals I, 46μ (33-52) apart; laterals III 19μ (9-19) arising posterolaterad (not more than 20μ laterad) of dorsals; dorsals IV as laterals I, 32μ (20-33) apart, laterals IV 19μ (15-22) long, distinctly farther from their dorsals than those of third tergum; external caudals II 7-22μ long, distinctly longer than other two pairs; apical portion of vagina with distinct sclerotized thickening that is globular to elliptical in shape. *Venter.* Hind margin of posterior ventral plate broadly and shallowly emarginate; apodemes III mesad of internal presternals and posterior median apodeme between apodemes III and IV weakly developed; internal presternals arising from apodemes III, external presternals arising about two areolar diameters anterior to apodemes IV, directly behind internal presternals; internal poststernals present, distinctly mesad of external presternals, external poststernals arising behind posterior terminations of apodemes V, laterad of external presternals; second axillaries immediately mesad of apodemes IV, slightly anterior to internal poststernals; all setae of posterior ventral plate flagellate, nude, similar in shape, short (7-18μ), longest on any one specimen never twice length of the shortest.

Legs (all measurements in μ). *Length.* Leg I, 90 (65-94); leg II, 72 (52-77); leg III, 72 (51-80); leg IV, 105 (69-110). *Width.* Leg I, 17 (13-18); leg II, 13 (9-13); leg III, 11 (8-12); leg IV, 11 (8-12). *Segment lengths.* tr I, 33 (24-36); ti I, 20 (14-22); ta I, 25 (16-25); ta II, 24 (16-25); ti III, 13 (8-14); cx IV, 30 (19-34);

tr IV, 26 (17-28); fege IV, 8 (6-9); ta IV, 32 (19-33). *Setation.* Leg I: cx 1T, tr 4T, fege 4T, ti 6T + 2S, ta 15 (T and S not separable in most instances): leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 7T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 7T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tarsus I with only two clavate or cylindrical solenidia, the rest setalike; solenidium 3 rodlike, curved, slightly longer than claw, arising at level of pedicelar base; solenidium 4 rodlike, straight, less than half as long or wide as 3, arising behind 3 but in apical third of segment; solenidium of tarsus II thickly rodlike, elongate, basal; solenidia of tibiae II and III small, clavate, arising at basal quarter of segment; tarsi II to IV constricted suddenly near most apical setae; coxa IV wider at base than at apex; solenidium of tibia IV small, weakly clavate, arising at basal quarter of segment; pulvilli II to IV shorter than respective claws; ratio of femurogenu IV to tarsus IV, approximately 1:3.1 to 1:4.0.

VARIATION. Little variation in setal placement, size, etc. is found in the type series. A great range in size exists, however, as is indicated by the presence of one very small specimen. The measurements of this specimen are available from the description since they are the smallest measurements in every case.

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Female holotype and two female paratypes (none gravid) from Howard County, Arkansas, June 8, 1936, W. F. Turner, collector. U. S. N. M. Lot Number 36-20984.

TYPE REPOSITORIES. Holotype and paratype No. 2 to the United States National Museum. Paratype No. 1 to the Snow Entomological Museum, The University of Kansas.

Trochometridium, new genus

(Figs. 29-40)

Type, *Trochometridium tribulatum,* new species.

This genus is erected to accommodate a single new species, which while showing affinities to both *Siteroptes* and *Pyemotes,* is very distinct from either. It resembles the former and differs from the latter in having a squarish gnathosoma bearing free palpi and dorsal, approximate stigmata, in that coxae IV are quadrate (although distinctly dicondylic), in the structural conformation of the gravid female, in that mass laying of eggs (accompanied by hysterosomal breakdown) occurs, and because the male mouthparts are vestigial.

It resembles *Pyemotes* and differs from *Siteroptes* in food habits, in possessing stout, easily distinguished chelicerae, in possessing a tripartite posterior ventral plate, in lacking a distinct posterior median apodeme, in that claw I of the female is sessile, and because leg IV of the male is furnished with two claws. It resembles neither of the above in that the first hysterosomal segment is tripartite, in its mating habits, in the sex ratio, in that the female trochanter I bears five setae rather than four, in the genital morphology of the male, and because leg I of the male is clawless. In consideration of the above, the genus seems clearly to belong in the Pyemotinae as a specialized form closely related to the Acarophenacinae.

Diagnosis. The females are easily separable from those of all other genera in that legs I are five-segmented, the recurved chelicerae are stout and distinct, the palps are free, and because the first hysterosomal segment is divided into one median and two lateral plates. Additional distinguishing characters are the presence of paired germaria between legs II and III, the dorsal, approximate, capitate peritremes, and the tripartite posterior ventral plate.

Males are distinguished from those of other genera in that the head, while reduced and lacking visible mouthparts, is bilobate rather than peglike, because leg I lacks claws but possesses a flaplike apical dorsal pulvillus, in that leg IV is more slender than legs I and II and bears two unequal claws (the smaller half the width of the larger), in that the aedeagus is ventral, short, bipartite, attenuate, declinate, non-cylindrical, and uncoiled, and because the opisthosoma is not modified (conelike or globelike) to accommodate the genital and clasping structures.

Description of Non-gravid Female. Length, approximately 250μ; width, approximately 150μ; width between anterior condyles of coxae III, approximately 115μ; hysterosoma elliptical-fusiform to elliptical, its posterior margin evenly rounded; body moderately sclerotized.

Gnathosoma. Squarish-fusiform, normally directed anteriorly, length approximately equal to width; palp free, distinct, with single small apical tooth; chelicera stout, styliform, recurved, easily visible; esophageal-pharynegeal pump absent.

Propodosoma. Dorsum. Inversely T-shaped, posterolateral margin rounded, anterior margin forming short, cylindrical cervix, posterior margin overlapping first hysterosomal segment; pseudostig-

mata located in anterior one-half; three pairs of propodosomal setae; peritremes dorsal and median, close together, nearly transverse, capitate medially; stigmatal openings arcuate, slit-like; esophageal structures not visible. *Venter.* Anterior ventral plate with six pairs of setae, ventrites I and II each with three pairs; external ventral I not forked, medial ventrals II much closer to externals II than to internals II; coxa I attached at nearly a right angle to longitudinal axis of body; apodemes II very strong, straight, complete medially, making angle of approximately 45 degrees with anterior median apodeme; anterior median apodeme extremely large, complete; posterior marginal apodemes weakly developed, distinct only laterally; pleated conjunctival band present between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First dorsal segment divided into one median and two lateral plates, each lateral plate bearing one seta, the median plate bearing a pair; fourth segment with two pairs of setae; fifth segment well developed but usually completely enclosed by fourth in dorsal aspect, bearing two pairs of setae; vulva apicoventral, its margin apparently greatly thickened and sclerotized; one omega-shaped internal genital structure always distinct (fig. 30). *Venter.* Posterior ventral plate tripartite, the two lateral portions overlapping each other mesad to coxae III, the median portion visible posteriorly and mesally as a triangular area beneath and between margins of lateral plates; posterior ventral plate with six pairs of setae; first axillary setae well anterior and mesad of anterior sternocoxal condyles of coxae III; second axillaries well inside and slightly anterior of coxae IV; external presternals well behind and well laterad of internal presternals, arising nearly half way between internals and first axillaries; external poststernals present, on median portion of posterior ventral plate; apodemes III not developed except at anterior sternocoxal condyles III, apodemes IV weak, joining coxae IV at anteromedial corners, progressing mesally and anteriorly to join with apodemes V, the latter joining coxae IV at posterolateral corners and proceeding anteromedially; posterior median apodeme absent; developing eggs in linear series sometimes visible in germaria situated laterally between legs III and IV; band of opisthosomal conjunctival pleats not visible on all specimens; opisthosomal venter entire, bearing a single pair of setae.

Legs. Well developed and long, margins of segments often with sclerotized areas of varying thicknesses; leg I five-segmented, about

twice as wide as leg II; tarsus I subconical, not wider than femurogenu I; large, sclerotized areas present along inner margin of tarsus I and medially near outer margin of tibia I; claw I single, stout, sessile, furnished with two stout thumbs; trochanter I with five setae, seta *c* long, aciculate, sparsely plumose, reaching beyond tip of tarsus; seta *d* hooked; sensory pegs of tibiae II and III present; tarsi II and III with eight tactiles; claws II to IV simple, subequal, a single short spur arising in apposition to them at apex of tarsus; pulvilli II to IV distinctly longer than claws; coxa III triangular; coxa IV quadrate, distinctly mesad of III; tarsus IV moderately long, tapering evenly, ratio of femurogenu IV to tarsus IV approximately 1:2.5.

Description of Gravid Female. Gnathosoma and propodosoma as described for non-gravid female but entire hysterosoma becoming physogastric, globular, 2 to 3 mm. in diameter.

Description of Male. Length, approximately 250μ; width, approximately 170μ; hysterosoma broadly oval, not sharply constricted in vicinity of legs III; conjunctiva granulose, especially laterally and ventrally between anterior and posterior ventral plates.

Gnathosoma. Length, approximately 20μ; width, approximately 35μ; reduced, bilobate, palps lacking, oral appendages and pharyngeal pump not visible, probably lacking as well.

Propodosoma. Dorsum. Dorsal plate well defined, short, subquadrate, enclosing reduced gnathosoma dorsally and laterally, its posterolateral margin bearing three pairs of setae. *Venter.* Apodemes I, II, and anterior median apodeme greatly enlarged, well sclerotized; anterior ventral plate with six pairs of setae, ventrites I and II each with three pairs.

Hysterosoma. Dorsum. Three dorsal plates present, the first bearing three pairs of setae, the second two pairs, and the most caudal two pairs. *Venter.* Posterior ventral plate entire; apodemes III, IV, and V well developed, joining equally distinct posterior median apodeme; external presternals well behind and outside of internal presternals; external poststernals present, slightly inside of and well behind internal poststernals; hind margin of posterior ventral plate indistinct; posterior margin of hysterosomal venter indistinct or distinct; posterior margin of opisthosoma sharply rounded; the halves of the apical aedeagus joining to form a short armature, the latter hooked ventrally near its apex and usually protruding slightly from the body; well defined genital capsule or spe-

cialized clasping structures lacking; two pairs of spinelike apical setae flanking aedeagal fissure, one pair of longer setae well ventrad and laterad of these.

Legs. All legs well developed, five-segmented; tarsus I lacking claw, with flaplike dorsal pulvillus; leg IV not greatly modified in size or form; coxa IV subquadrate; trochanter IV not distinctly arcuate; tarsus IV well developed, with two claws, one similar in size to claws of other legs, other twice size of first.

Trochometridium tribulatum, new species

DESCRIPTION OF NON-GRAVID FEMALE. Body elliptical-fusiform, length, 247μ (218-295, $\bar{X} = 253.08 \pm$ S. E. 6.59); width, 146μ 127-187, $\bar{X} = 153.63 \pm$ S. E. 4.88); distance between coxae III, 115μ (108-124, $\bar{X} = 115.22 \pm$ S. E. 1.78); at least posterior portion of propodosomal dorsum and median portion of first dorsal segment coarsely punctate.

Gnathosoma. Squarish-fusiform, large, approximately 48 x 48μ; all gnathosomal dorsals present, internals tiny, arising anterior to and slightly laterad of externals; solenidium II tiny, appearing as a palpal tooth; solenidium I subapical, lanceolate; one tiny seta present on oblique inner face of palpal apex; second palpal seta one-third of length of palp from apex, distance between first and second palpal setae about 7μ; esophageal pump not visible.

Propodosoma. Dorsum. Width between pseudostigmatal sockets 69μ, (63-70, $\bar{X} = 67.00 \pm$ S. E. 0.88); peritremes nearly transverse, irregularly shaped, capitate medially, about 20μ center-to-center, most mesal margins about 3μ apart; stigmatal openings slitlike, arcuate; pseudostigmata barely in anterior half of propodosoma, line drawn between them about 5μ in front of stigmatal setae; propodosomal setae variable, sparsely short-plumose, stigmatals directly below median third of peritremes, about 26μ long; anterior pseudostigmatals short, about 14μ, arising mesad and posterior to internal pseudostigmatal sockets; posterior pseudostigmatals about 70μ long. *Venter.* Six pairs setate, ventrites I and II each with three pairs; median and internal ventrals II longer than rest, 40 to 50μ, internal ventrals I shortest, 12 to 17μ; internal ventral II well anterior to other setae of that ventrite; hind margin of anterior ventral plate irregularly scalloped, not heavily sclerotized, posterior marginal apodemes absent except at sides.

Hysterosoma. Dorsum. Dorsal setae varying in size, always sparsely plumose; anterior portions of all three sections of the first

segment covered by posterior margin of propodosoma; dorsal setae I well posterior to laterals I, arising from posterior third of segment, stout, 41μ, 38-43, $\bar{X} = 39.43 \pm$ S. E. 0.40); laterals I longer, about 75μ, otherwise similar to dorsals I; dorsals II as stout as dorsals I and longer, 48μ, (41-48, $\bar{X} = 44.57 \pm$ S. E. 0.68) slightly laterad of latter, spaced about 36μ apart; all setae of segment III equally short, 17μ (17-20, $\bar{X} = 18.21 \pm$ S. E. 0.35), the dorsals about 9μ apart and slightly anterior to laterals; dorsals IV approximately 20μ apart, 51μ (43-54, $\bar{X} = 48.14 \pm$ S. E. 0.99) long, stout, formed as setae of segment I, laterals IV on transverse line with dorsals IV, only a third their length; segment V with two pairs of short, weakly plumose ventral setae about 12μ in length, first pair flanking the vulva, second pair nearly a setal length anterolateral. *Venter.* Lateral divisions of posterior ventral plate arcuate along their mesal margins, these margins overlapping each other in the vicinity of legs III; lateral portions of posterior ventral plate bearing all setae except external poststernals, these borne on triangular median portion of posterior ventral plate (fig. 30); anterior condyles of coxa III well sclerotized, but apodemes III absent; apodeme IV joining apodeme V mesally, delimiting a bell-shaped area which bears the second axillaries and internal poststernals; posterior median apodeme indistinct (distinct as short apophysislike invagination); first axillary well anterior and mesad of anterior condyle of coxa III, second axillary immediately anterior and mesad of anteromedian corner of coxa IV; internal poststernals well (about 10μ) anterior to anterolateral corner of coxa IV, about one and one-half times as far apart as internal presternals; all setae of posterior ventral plate thin, flagellate, sparsely spiculate, 25 to 35μ long; opisthosomal venter distinct, cleft medially, cleft often appearing to contact internal genital sclerotization; setae of opisthosomal venter approximately 15μ long, about as far apart as internal ventrals II.

Legs (all measurements in μ). *Length.* Leg I, —[5] (98-122, $\bar{X} = 113.50 \pm$ S. E. 2.99); leg II, 113 (110-118, $\bar{X} = 113.90 \pm$ S. E. 0.78); leg III, 125 (125-128, $\bar{X} = 125.86 \pm$ S. E. 0.44); leg IV, —[5] (139-152, $\bar{X} = 145.17 \pm$ S. E. 1.82). *Width.* Leg I, 31 (22-32, $\bar{X} = 28.92 \pm$ S. E. 0.79); leg II, 19 (14-21, $\bar{X} = 17.84 \pm$ S. E. 0.47); leg III, 18 (13-18, $\bar{X} = 16.61 \pm$ S. E. 0.50); leg IV, 20 (13-20, $\bar{X} = 18.08 \pm$ S. E. 0.58). *Segment lengths.* tr. I, 42 (40-43, $\bar{X} = 41.78 \pm$ S. E. 0.44); fege I, 22 (20-23, $\bar{X} = 21.44 \pm$ S. E. 0.58); ta II, 35

5. Measurement not possible on holotype.

(33-39, $\bar{X} = 36.67 \pm$ S. E. 0.65); fege II, 19 (18-21, $\bar{X} = 19.18 \pm$ S. E. 0.32); tr IV, 41 (41-45, $\bar{X} = 42.66 \pm$ S. E. 0.42); cx IV, 23 (22-25, $\bar{X} = 23.64 \pm$ S. E. 0.25); fege IV, 21 (19-22, $\bar{X} = 20.18 \pm$ S. E. 0.26); ta IV, 52 (48-56, $\bar{X} = 53.33 \pm$ S. E. 0.72). *Setation.* leg I: cx 1T, tr 5T, fege 5T, ti 6T + 2S, ta 7T + 6S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 8T + 1S; leg III: cx 1T, tr 2T, fege 3T, ti 4T + 1S, ta 8T; leg IV: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 7T.

Trochanter I with five setae, the most basal and medial hooked, the apical external dorsal long and whiplike, sparsely plumose, reaching apex of leg or beyond; tibia I distinctly wider than any other leg segment; tarsus I tapering, subconical; solenidium of tarsus II bearing an apical prickle; solenidia of tibiae II and III thin, setalike, 7 to 10μ long, solenidium of tibia IV setalike, longer, 13 to 15μ; coxa IV subquadrate; tarsus IV evenly attenuate, width at apex about three-fourths that of base; ratio of femurogenu IV to tarsus IV approximately 1:2.5.

DESCRIPTION OF MALE. Body broadly oval; length (excluding gnathosoma) 250μ (240-315); width at widest point, 170μ (variation not measurable); sclerites impunctate; conjunctival areas distinctly granulose.

Gnathosoma. Reduced; length, 28μ (variation not measurable); width, 36μ (35-38); bilobate, lobes connected anteriorly by an indistinctly defined membrane. *Setation.* Three pairs of short, dorsal tactiles, one pair of short, one pair of long ventral tactiles, one pair of short, rodlike, ventral sensory setae.

Propodosoma. Dorsum. Weakly sclerotized except for dorsal plate; length of dorsal plate 37μ (variation not measurable); width of dorsal plate 55μ (55-69); dorsal plate with three pairs of setae, anterior pair short, 13μ (13-15), second pair longer, 21μ (20-28), posterior pair at least thrice length of median pair, 72μ (72-105). *Venter.* Median and internal setae of ventrites II nude and flagellate, 100 to 140μ, external ventrals II short, weakly plumose, 18μ (16-20).

Hysterosoma. Dorsum. First hysterosomal plate transversely elliptical, largest of three, overlapping second; lateral margins of second plate narrowing posteriorly, overlapping third; third plate truncate posteriorly, much smaller than second. *Setation.* All setae of first and second dorsal plates weakly short-plumose, setae of third dorsal plate thick and nude; most anterior dorsals I 19μ (19-38) long, posterior dorsals I 82μ (81-151), laterals I 122μ (122-

183); dorsals II 15μ (15-26), laterals II 53μ (33-81); dorsals III short, spiniform, divergent, 5μ (5), laterals III straight, bladelike, 15μ (15). *Venter.* All setae of posterior ventral plate short, thin, barely spiculate, 12 to 23μ long; external presternals usually at least twice as far apart as internal presternals; opisthosomal ventral setae longer and stouter than setae of posterior ventral plate, 28μ (28-46) long, about one and one-half times as far apart as internal poststernals; aedeagus apicoventral, short, approximately 13μ long, bipartite, attenuate, declinate, uncoiled, its bulbose bases divergent within the body; aedeagus usually protruding slightly from aedeagal fissure located posteriorly in fifth segment; two pairs of caudal setae arising from margin of segment V, inner pair stout, divergent, bladelike, 4μ (4-5) long, outer pair straight, spiniform, 3μ (3-4) long, a single pair of short setae about 10μ long (opisthosomal ventrals?) arising well anterior and laterad of these.

Legs (all measurements in μ). *Length.* Leg I, 130 (127-168); leg II, 154 (144-216); leg III, 151 (149-211); leg IV, 118 (118-166). *Width.* Leg I, 25 (25-31); leg II, 26 (26-33); leg III, 17 (17-23); leg IV, 21 (21-28). *Setation.* Leg I: cx 1T, tr 5T, fege 5T, ti 6T + 2S, ta 7T + 8S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 8T + 1S; leg III: cx 1T, tr 2T, fege 3T, ti 4T + 1S, ta 8S; leg IV: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 7T.

Femurogenu II with a single spurlike seta, tibia II with a spurlike seta stouter than that of femurogenu; tarsus II with a pair of stout spurlike setae; trochanters I and II each with a single whiplike seta; sense pegs of tibiae II, III, and IV thin and setalike, 7 to 12μ long; sensory peg of tarsus II bulletlike, 6 to 12μ long; apical sensory setae of tarsi II to IV small, thin, usually difficult to see.

Distribution. Oregon to Maryland and as far south as Matamoros, Tamaulipas, Mexico.

Type Material. Holotype female, allotype male, six female (nos. 1, 2, 8, 9, 11, 12) and three male (nos. 14, 15, 16) paratypes from Logan, Green Canyon) Cache County, Utah, July 31, 1956, G. E. Bohart, A. Løken, E. A. Cross, from cells of *Halictus farinosus* Smith.[6] Four female paratypes, (nos. 3, 4, 5, 10) same locality and collectors, July 18, 1956, from mesosoma of *Sphecodes arvensiformis* Cockerell.[6] One female paratype (no. 7) from Lawrence, Douglas County, Kansas, July 15, 1957, A. F. Shinn, from cell of *Calliopsis andreniformis* Smith.[7] One male paratype (no. 17) same locality,

6. Det. P. H. Timberlake, Citrus Experiment Station, Riverside, Calif.
7. Det. A. F. Shinn, Stephen F. Austin St. Coll., Nagadoches, Texas.

collector, and host as preceding, but dated July 27, 1957. One female paratype (no. 6), Fort Meade, Anne Arundel County, Maryland, August 3, 1956, S. R. Joseph, from legs and metasoma of "mutillid." One female paratype (no. 13) 5 mi. NE Adrian, Malheur Co., Oregon, July 31, 1958, R. Eppley, from cell of *Nomia* (*Acunomia*) *melanderi* Cockerell.[8]

TYPE REPOSITORIES. Holotype, allotype, one male (no. 14) and eight female (nos. 4, 6, 7, 9, 10, 11, 12, 13) paratypes in the Snow Entomological Museum, The University of Kansas; one male (no. 17) and one female (no. 3) paratype in the United States National Museum, Washington, D. C.; one male (no. 16) and one female (no. 2) paratype in the Zoologisches Institut der Universität Erlangen, Erlangen, Germany; one male (no. 15) and one female (no. 5) paratype in the British Museum (Natural History), London, England; one female paratype (no. 1) in Oregon State College collection, Corvallis, Oregon; one female paratype (no. 8) in the private collection of the author.

SPECIMENS EXAMINED AND HOSTS. In addition to the type material the following specimens have been examined: IOWA: Sioux City, *ex Calliopsis andreniformis.* NEBRASKA: Lincoln, *ex Calliopsis andreniformis.* TAMAULIPAS: Matamoros, *ex Nomia* (*Epinomia*) *nevadensis bakeri* Cockerell. TEXAS: Cotulla, *ex N. n. bakeri.*

HABITS. As far as is known, the species is a parasite of larval bees. Observations concerning its life history were made by the author while studying a nesting area of *Halictus farinosus* Smith, a large, soil-nesting, social halictine bee, in Green Canyon, Cache County, Utah, during late July and early August of 1956. Several cells of this bee were found to be infested with *Trochometridium tribulatum,* including two that contained gravid female mites and eggs or eggs and immatures. The contents of the cells were reared in the laboratory and observations were made on their development.

The eggs are large (160-200μ), spherical, translucent to milky-white. They are deposited in bunches within the cell, apparently normally, through the vulva, rather than through the rupture of the hysterosomal wall as described for *Siteroptes cerealium.* It resembles this species, however, as well as members of the genus *Pyemotes* in the complete suppression of active immature stages. The egg hatches into a quiescent form which gradually increases in size, changes shape and color, and molts into an active adult mite of either sex.

8. Det. E. A. Cross, Northwestern State College, Natchitoches, La.

The shell splits, disclosing the quiescent embryo enclosed within an embryonic sheath. At this point only the two anterior pairs of legs protrude, and the young embryo resembles a minute ptyctime. Embryos at this stage possess two pairs of clawless hysterosomal lobes and presumably pass the larval stage while within the chorion. As the embryo grows, it casts aside the halves of the shell and takes on a more definite shape, gradually acquiring a pale reddish tinge. Both sexes at this stage are fusiform, having the two anterior pairs of legs extended forward and touching each other apically, the two posterior pairs extending behind, also touching apically. Such embryos appear to have only one enveloping membrane. The adults emerge from this membrane head first, and mites having only the first two pairs of legs free are commonly seen scraping against the substratum to peel away the posterior half of this enveloping sac. Although it was not possible to ascertain the exact duration of the immature stages, some information was obtained. An egg mass collected on July 31 from a bee cell which also contained a second gravid female mite (this mite proved to contain no mature eggs when dissected) was observed in the laboratory. On August 2, the first egg hatched, and by August 8th most of the viable eggs had hatched. On this latter date several adult males were already present. By August 10th, both males and females were present in some numbers, males comprising about 40 to 45 percent of the total population. On August 16th, approximately three-fourths of the mites had reached adulthood, at which time the total number of adults was 210. Sixty (29 percent) of these were males. Male mortality was seen to begin within two days of the time of their emergence, and what percentage survived to contribute to the above total is not known. Observations made of infested cells shortly after the completion of mite emergence indicate that the percentage of males is very low (2 percent), or that males are absent entirely. It appears, therefore, that males emerge first and die first, their complete disappearance coinciding with the time of emergence of the latest females. The male/female ratio is high, equalling or surpassing unity in the early half of the emergence span. In *Siteroptes cerealium*, the usual male/female ratio is .04 to .05, in *Pyemotes* species, .035 to .0375 (after Herfs, 1926).

The two sexes differ as greatly in their locomotory movements as in their physical appearance. Females exhibit a steady gait, usually utilizing only legs II and III. Legs IV are occasionally used in walking, but generally seem to serve as organs of balance

under conditions involving smooth terrain. The huge first pair of legs are used as sensory appendages in the same manner as those of Scutacaridae. They are carried slightly diverging before the advancing mite, often making alternate "pawing" motions in the air, or they may be tapped on the substrate as the mite proceeds. On several occasions the pawing motions were seen with legs I held vertically above the propodosoma. Males, on the other hand, are excessively awkward. Apparently, all four pairs of legs are used for locomotory purposes, but in an uncoordinated manner. Movements are halting and clumsy, often consisting only of slow, turning motions, and they seem incapable of walking any great distance. No differences in gait were observed when males were isolated in separate dishes. (Perhaps the excessive awkardness of the male may help to explain the comparatively high male/female sex ratio in the species.)

Mating was observed in this species, the process differing considerably from that described for *Siteroptes* and *Pyemotes*. As soon as males emerge, they begin to wander about, during which time they may attempt to mate with any females encountered. It is probable that, as in *Pyemotes*, they are not stimulated by inseminated females, since they make no attempt to copulate with many of the females passing within reach. Perhaps this may be a behavioral rather than a physiochemical response on the part of the female, since many females seem to actively avoid or rebuff the males. Having found a partner, the male slides underneath her body, still with his ventral surface toward the substrate. Reaching upwards with legs I and II, he grasps the anterior portion of the female hysterosoma and holds the female in this position during copulation, her venter pressed tightly against his dorsum. The apex of the male opisthosoma is then directed upward to make contact with the vulva of the female. Contact seems to last but an instant. In at least one instance, the female was newly hatched, having just previously shed her embryonic membrane. Males were never seen to pick up the quiescent nymphs and attempt copulation as has been described for related forms.

Although certain parts of the life history seem clear, much is unknown and the following account is largely speculative.

Young, presumably mated females are found within the nests of the host. Although they tend to congregate in masses within the cells in which they are born, this behavior must be later modi-

fied so that they escape from the cells and disperse inside the bee burrows. There they may find the original mother bee (in the case of *Halictus farinosus*), or the succeeding generation of bees emerging the same year, or (*Nomia, Calliopsis*) they overwinter within the burrow to find the brood emerging the following spring. In any event, it seems clear that mites leaving the nest usually are dispersed by the adult bees or their parasites or inquilines. Young female mites have been found clinging to the mesosoma or head of adult *Halictus farinosus* Smith, *Nomia nevadensis bakeri* (Cockerell), *Sphecodes arvensiformis* Cockerell, and an unidentified mutillid. Concerning the latter two, the first is a known parasite of *Halictus farinosus* and it is likely that the second is also a bee parasite. In searching for a suitable host cell, the female *S. arvensiformis* may puncture the caps of a sealed cell (G. Bohart and Cross, unpublished). It is possible that this behavior may facilitate the dispersal of mites from infested cells.

The young females must obviously find a host larva. Those attached to female bees or bee parasites may drop off into cells newly constructed or provisioned and wait, probably inside the cell, for the bee larva to reach the proper stage of development. The author has seen slides of young female mites labelled "from the larva of *Calliopsis andreniformis*." No cells found by the author in Utah contained both mites and bee larvae. Presumably the host is killed, perhaps by a toxic salivary secretion similar to that of *Pyemotes* sp. A. Shinn (in litt.), working with *Calliopsis andreniformis* in Kansas in 1957-58, reports the same finding. At least in *H. farinosus* the larva may be killed before it finishes feeding, as indicated by a small amount of pollen found in at least one parasitized cell of *H. farinosus*. It is presumed that the female feeds by first piercing the skin of the host with the needlelike chelicerae, then sucking body fluids. Of interest is the fact that both Shinn (in litt.) in Kansas and the author in Utah have never found more than two gravid female mites in a bee cell.

As the female feeds, the entire hysterosoma begins to swell and become globelike, this continuing until she has increased her original size many times. The diameters of the hysterosomata of gravid specimens from Utah and from Kansas are 2.3 and 3.0 mm., respectively. Within this enormously distended sphere, the eggs are formed.

Resinacarus Vitzthum

Resinacarus Vitzthum, 1927, Sitzungsberichte der Gesellschaft Naturforschender Freunde Berlin, 1927, pp. 89-110. Type, *Resinacarus resinatus* Vitzthum, 1927, by original designation.

The single species *resinatus* included in this genus has not been seen since it was originally described. *Resinacarus* will therefore not be described herein and the reader is referred to the original description.

Partly due to Kramer's (1877b) incorrectly ascribing (see p. 156) but two pairs of dorsal propodosomals to *Pygmephorus spinosus,* confusion has existed in assigning forms to *Resinacarus.* Particularly in the United States, species properly belonging to *Pygmephorus sensu stricto* (as defined in this paper) have been incorrectly placed in this genus. In actuality, *Resinacarus* appears to be a unique form and may be separated from the remaining genera in the family by the characters given in the above keys.

The male of *Resinacarus* resembles that of some Pyemotinae and some Acarophenacinae in the following respects: functional gnathosoma present; leg IV similar to that of the female; pronounced genital capsule lacking; propodosoma with four pairs of dorsal setae.

The female resembles some Acarophenacinae as well as some Pyemotinae and differs from those of the Pygmephorinae in that coxa IV is triangular and similar to coxa III, because apodemes IV arise from the anterior sternocoxal condyles of legs IV, and in possessing a pair of opisthosomal sternals; it resembles the Acarophenacinae and differs from the other two subgenera in having only three pairs of anterior sternal setae and four pairs of posterior ventral setae; it resembles some Pygmephorinae and Pyemotinae and differs from the Acarophenacinae in that coxa I appears to arise only slightly obliquely to the longitudinal axis of the body, in that the gnathosoma is elongate, free, and decumbent, and in body shape.

In consideration of the above, the author tentatively places *Resinacarus* as a specialized genus (fused tibiotarsus I, loss of two pairs of ventral setae) within the subfamily Pyemotinae.

Vitzthum took *resinatus* from tubes bored in spruce resin by *Myolepta* sp. and another unidentified species of syrphid fly. He believed the mite to be associated with the fungus *Sporotrichum flavissimum,* therefore similar to *Siteroptes* in food habits.

Acarophenacinae, new subfamily

DESCRIPTION OF NON-GRAVID FEMALE. Small mites, usually 200μ long or less, rarely 300μ; shape oval to short-fusiform, posterior margin of hysterosoma usually sharply rounded; integument weakly to moderately sclerotized, lacking "pebblings" or scalelike engravings; most lateral portions of posterior ventral plate not striate.

Gnathosoma. Distinct and normally directed anteriorly or hidden within propodosoma; palps fused to gnathosoma, not distinct; chelicerae enlarged, distinct, needlelike or bladelike.

Propodosoma. Dorsum. Entire or bipartite; pseudostigmata present or (usually) absent; two or three pairs of dorsal propodosomal setae present; posterior margin of propodosoma meeting or overlapping anterior margin of first hysterosomal tergum; esophageal "finned structures" not visible, probably lacking. *Venter.* Anterior ventral plate with three pairs of setae or less; secondary transverse suture lacking.

Hysterosoma. Three to five visible segments, segment V reduced, sometimes vestigial; segment V, if distinct, with two pairs of setae or fewer; posterior portion of vaginal wall not sclerotized or enclosed within enlarged, globose to elliptical pumplike structures; definitive anterior and posterior genital sclerites absent but various internal opisthosomal sclerites sometimes present; opisthosoma short, usually not much longer than distance between anterior margin of coxa III and posterior margin of coxa IV; setae of opisthosomal venter present or absent.

Legs. Leg I 4 or 5 segmented, arising at nearly a right angle to the longitudinal axis of the body or distinctly obliquely; trochanter I with three or four setae, seta *c* setiform; claws I and IV, II to IV, or I to IV may be absent or all claws may be present; pinnacula absent; coxa IV subcordate or bandlike, never quadrate or rectangular; tarsus IV not greatly elongate, never more than three and one-half times length of fermurogenu IV.

Key to the Genera of the Subfamily Acarophenacinae (Females)

1(*a*). Leg I with five segments; pseudostigmata present.... *Caraboacarus,* p. 130
1(*b*). Leg I with four segments; pseudostigmata absent.....2
2(*a*). Leg IV with claws; peritremes opening dorsally; dorsal propodosomal U-shaped apodeme lacking..... *Paracarophenax,* p. 132
2(*b*). Leg IV without claws; peritremes opening anteriorly; dorsal, propodosomal U-shaped apodeme present.....3

3(*a*). Tibiotarsus I with stout, sessile claw; posterior ventral plate with five pairs of setae ..... *Acarophenax*, p. 138
3(*b*). Tibiotarsus I clawless; posterior ventral plate with three or four pairs of setae ..... *Adactylidium*, p. 142

Caraboacarus Krczal

(Figs. 41-42)

Caraboacarus Krczal, 1959, Beiträge zur Systematik und Ökologie mitteleuropäischer Acarina. Bd. I: Tyroglyphidae und Tarsonemini, Teil 2, p. 570. Type, *Caraboacarus stammeri* Krczal, 1959, by original designation.

This genus is known from various carabid genera in Europe and the central United States. Although possessing several characters considered to be specialized, including the loss of claws I and IV, loss of the opisthosomal sternals, the fusion of tibia and tarsus IV, small size, the oblique articulation of coxae I, the possession of only two pairs of propodosomal setae, and the modified, paddlelike ventral setae, it is tentatively placed as the most primitive form in the subfamily because legs I are five-segmented, pseudostigmata are retained, the anterior ventral plate bears three pairs of setae, the posterior plate bears six pairs, gnathosoma is free, propodosomal dorsum is entire, trochanter I has four setae, tarsus II has seven setae, the solenidia of both tibiae II and III are present, and because the fifth segment is relatively well developed.

Despite its wide host range and distribution, the genus is known to include but two species, one undescribed. Only the non-gravid females are known. *Diagnosis.* Females may be differentiated from those of all other genera by the following combination of characters: legs I five-segmented, gnathosoma free, at least twice as wide as long, palps fused, body short-fusiform, opisthosoma very short, projecting behind posterior margins of coxae IV only about as much as gnathosoma projects forward from anterior margins of coxae I.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 160 to 173μ; width 111 to 120μ; width between anterior condyles of coxae III 66 to 77μ; hysterosoma ovate-fusiform; body weakly sclerotized or not, with or without coarse punctures.

Gnathosoma. Distinct, bow-shaped, at least twice as wide as long, directed anteriorly; palp indistinct, fused with gnathosoma; chelicera stout, recurved, bladelike, easily visible; pharyngeal-esophageal pump present but dorsal rather than ventral.

Propodosoma. Dorsum. Broadly trapezoidal, nearly rectangulate; posterior margin meeting or hidden beneath first hysterosomal

segment (In mounted specimens of the same series, both conditions occur. Since the overlap between the two sclerites is small, these discrepancies probably occur during mounting); prominent dorsal U-shaped apodeme lacking; pseudostigmata present, normal, located in posterior one-half, arising well laterad; two pairs of propodosomal setae, one pair of pseudostigmatals missing, remaining pair less than twice length of stigmatals; peritermes circular to oval, situated at anterolateral corners of dorsum, often hidden or indistinct; two pairs of large, sclerotized "tubercles" present, one pair anteromesad of stigmatals, a second, larger pair behind pseudostigmatals; internal atria dorsal, elongate, moderately prominent. *Venter.* Ventrites I lamellate anteriorly or normal, sometimes (*stammeri*) with a pair of circular, suckerlike structures; anterior ventral plate with three pairs of setae, ventrites I with one pair, ventrites II with two pairs, external ventrals I lacking; line of articulation of coxa I oblique to longitudinal axis of body; apodemes II wide, becoming platelike laterally, arcuate, complete, making angle of about ninety degrees with anterior median apodeme, latter well developed, extending posteriorly to line drawn between posterior condyles of coxae II; pleated conjunctival membrane between propodosoma and hysterosoma not visible; posterior marginal apodemes well developed medially, incomplete at sides.

Hysterosoma. Dorsum. First segment entire, meeting or extending slightly over posterior margin of propodosoma; fourth segment with two pairs of setae; segment V reduced, cuplike, concealed dorsally by fourth or nearly so, bearing one or two pairs of setae, inner pair tiny, spinelike, often indistinct; vulva apical; genital sclerotizations variable, seemingly dependent upon mount. *Venter.* Posterior ventral plate entire, bearing six pairs of setae, at least one pair modified spinelike; second axillaries nearly directly mesad of anterior condyles of coxae IV; external presternals well laterad of and posterior to internal presternals, much closer to latter than to first axillaries; external poststernals arising directly behind but some distance from internal poststernals, near line drawn between most mesal margins of coxal foramina IV; apodemes III well developed, arcuate, incomplete medially; apodemes IV also well developed, straight, complete or nearly so, arising near posterior margins of coxae III and proceeding anteromedially at angle of about 45 degrees; apodemes V absent; posterior median apodeme distinct, its posterior termination in vicinity of internal poststernals, band of

opisthosomal conjunctival pleats visible or not; opisthosoma characteristically short, much shorter than distance between anterior margins of coxae III and posterior margins of coxae IV; opisthosomal venter entire, one pair of setae present or not.

Legs. Well developed, margins of segments often with well sclerotized areas of varying thickness; leg I with five segments, distinctly shorter and thinner than leg II; tarsus I short and tapering, narrower than other segments of leg; lateral sensory spot absent; claw I lacking; tibia about same breadth as femurogenu; trochanter I with four setae, seta *c* stout, long, aciculate, reaching nearly to largest tarsal solenidium; seta *e* peglike or clavate; trochanter II with three setae, femurogenu II with three; trochanter III with two setae, femurogenu III with three; tarsus II with seven setae and a sensory peg, tarsus III with seven setae; solenidia of tibiae II and III present, basal; claws II and III present, short and stout, with a large mesal lobe; claws IV lacking; pulvilli II and III much longer than claws; coxa III subcordate, coxa IV bandlike, distinctly mesad of coxa III; tibia and tarsus IV fused; tibiotarsal suture distinct half way around leg; most elongate seta of leg IV dilated bladderlike basally.

HABITS. Because of the greatly enlarged chelicerae of these mites, it is probable that they are parasites. All specimens known to date have been taken from beneath the elytra of various carabid beetles, principally of the genera *Harpalus* (in Europe) and *Agonoderus.*

SPECIMENS EXAMINED. Two species (one probably *stammeri*) from Kansas and Michigan, from the following hosts: *Agonoderus comma* Fabricius,[9] *A. pallipes* Fabricius, *A.* sp., "large black carabid," "small black carabid."

Paracarophenax, new genus

(Figs. 45-47)

Type, *Paracarophenax dybasi,* new species.

This genus includes at least four species, two of which are undescribed. One of these, *P. dybasi,* is described herein.

P. dermestidarum (Rack) and *P. bambergensis* (Krczal) are found upon various dermestids and upon nitidulids, respectively. The habitat of *P. dybasi* (in debris under decaying fruit) suggests a host similar to the latter. An undescribed species near *P. dybasi*

9. Det. G. E. Ball, 1960.

has been taken from a Panamanian cerambycid. Rack (1959), gives an excellent account of *P. dermestidarum*.

Members of the group are closely related to *Acarophenax* but are considered less specialized in that claws I to IV are retained, in that the propodosomal arcula is less specialized, because segment V is relatively well developed and bears a pair of setae, and because the solenidium of tibia II is retained. In addition, the peritremes are dorsal in some (but not all) species.

The male of only one species, *P. dermestidarum*, is known.

DIAGNOSIS. Females differ from those of all other genera in the family by the following combination of characters: anterior ventral plate with only two pairs of setae; gnathosoma concealed within the propodosoma or nearly so; chelicerae stout, easily visible; legs II to IV with claws.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 200 to 300μ; width, 98 to 180μ; width between anterior condyles of coxae III 65 to 110μ; hysterosoma subovate, its posterior margin narrowly rounded; body weakly sclerotized and without coarse punctae.

Gnathosoma. Outlines indistinct, nearly completely enclosed within propodosoma, not visible in dorsal aspect; palpi fused with gnathosoma, indistinct; chelicerae stout, styliform, recurved, easily visible; elongate, spindle-shaped pharyngeal-esophageal pump present, often indistinct, extending posteriorly as far as mesal portions of coxae II.

Propodosoma. Dorsum. Dorsal propodosomal plate broad, shield-like, overlapping bases of legs II, projecting anteriorly, lobelike, between legs I, sometimes ventrally to gnathosoma; posterior margin overlapping first hysterosomal segment; dorsal, U-shaped apodeme lacking; peritremes dorsal or dorsolateral, located near anterolateral extremities of propodsoma, not enclosing gnathosoma laterally; internal atria drop-shaped, ill defined or not visible; pseudostigmata absent; two or three pairs of propodosomal setae, anterior pairs absent or distinct, if distinct then less than half as long or wide as remaining pairs, located laterad of cheliceral bases. *Venter.* Anterior ventral plate with two pairs of setae, ventrites I with one pair, second pair on or approximate to apodemes II; ventral externals I lacking; coxa I attached at a right angle to longitudinal axis of body or slightly oblique; apodemes II moderately to weakly developed, long, straight, incomplete medially, sometimes narrowly so, making angle of about 45 degrees to longitudinal plane of body;

anterior median apodeme absent to well developed; pleated conjunctival band between propodosoma and hysterosoma indistinct; posterior marginal apodemes ill defined.

Hysterosoma. Dorsum. First dorsal segment entire, overlapped anteriorly by propodosoma; third segment with one or two pairs of setae; fifth segment reduced, cuplike, usually not completely hidden beneath fourth in dorsal aspect, bearing a single pair of apicoventral setae; vulva apical, apical portion of vagina not heavily sclerotized or enclosed in heavily sclerotized pumplike structure. *Venter.* Posterior ventral plate with five pairs of setae, entire or with tripartite posterior margin; second axillary well mesad of anterior sternocoxal condyle IV; one pair of poststernals lacking; apodemes III weak or lacking except at anterior sternocoxal condyles of coxae III; apodemes IV weakly to moderately developed, nearly straight, incomplete medially, arising from posterior margin of coxae III and proceeding anteromedially; apodemes V absent; band of pleated opisthosomal conjunctiva indistinct; opisthosoma short, distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV; opisthosomal venter entire, bearing a single pair of setae.

Legs. Well developed and long; leg I four-segmented, distinctly stouter than remaining legs; tibiotarsus I subelliptical to rectangular, distinctly wider than other segments of leg; large, rounded, mediolateral sclerotized area near outer margin of tibiotarsus I midway between base and claw; claw I single, stout, sessile, furnished with a large, toothed thumb; trochanter I with three setae, seta *c* stout and aciculate, not or scarcely reaching tibiotarsal sensory spot, seta *d* arcuate; trochanter II with three setae, femurogenu II with one or three; trochanter III with one or two setae, femurogenu III with one or three; solenidium of tibia II present, that of tibia III absent; tarsus II with six tactile setae and a sensory peg, tarsus III with six tactiles; solenidum of tarsus II in basal third of segment; pretarsi II to IV elongate, two-thirds to nearly as long as tarsi; claws II to IV well developed, simple, pulvilli II to IV also well developed; coxa III short-triangular in ventral aspect, coxa IV broadly crescentic in ventral aspect, distinctly mesad of coxa III; femurogenu IV with one or two setae; tarsus IV only slightly longer than tibia IV, tapering evenly; ratio of femurogenu IV to tarsus IV about 1:2.

DESCRIPTION OF GRAVID FEMALE.[10] Gnathosoma as described for

10. Specimens of these stages not seen; information taken from original description of *Acarophenax dermestidarum* (Rack).

non-gravid female; propodosoma and hysterosoma becoming physogastric and spherical, sometimes reaching 700μ.

DESCRIPTION OF MALE.[10] Similar to that of *Acarophenax;* slightly smaller than female; posterior margin rounded; body dorsoventrally flattened; opisthosoma not greatly modified to form connate or trapezoidal genital capsule.

Gnathosoma. Hidden within propodosoma, chelicerae functional.

Hysterosoma. Venter. Generally agreeing with description of *Acarophenax* but appearing to possess two pairs of setae rather than two pairs of suckers on genital plate; apicoventral suckers also seemingly absent; apodemes III and IV are complete medially or nearly so.

Legs. All legs shorter than those of female, leg IV subequal to or slightly longer than leg III, otherwise agreeing with the description of *Acarophenax.*

Species thought to belong in *Paracarophenax:*

bambergensis (Krczal, 1959) (*Acarophenax*)
dermestidarum (Rack, 1959) (*Acarophenax*)
dybasi, new species
ipidarius (Redikortsev, 1947) (*Pediculoides*)

HABITS. Unknown except for the excellent account of the habits of *P. dermestidarum* (Rack). In general, the life history of that species agrees well with that of *Acarophenax tribolii.* Several interesting differences, and points not noted by Newstead & Duvall should perhaps be mentioned here, however.

Females of *P. dermestidarum* differ from those of *A. tribolii* in their locations on the adult host, those of the latter occurring principally under the wings, those of the former preferring the venter, principally that of the thorax. Concerning the question of the young females of *dermestidarum* parasitizing adult beetles, see p. 141. Unlike those of *A. tribolii, dermestidarum* females will leave their adult host and actively seek food if the latter are incapable of oviposition. Rack mentions that complete physogastry may be attained following the consumption of about half the contents of a single beetle egg, the active feeding period lasting 24 to 30 hours. The number of offspring per female is higher than in *tribolii,* and ranges from 3 to 27. As in the latter species it is directly correlated with the amount of physogastry attained by the mother.

It was ascertained by Rack that mating in *P. dermestidarum* occurs within the body of the mother, only a single male being

produced in any one female. After impregnating its sisters, this male often initiates the maternal hysterosomal breakdown and subsequent birth of the offspring by pushing its way through the body wall of its mother. If neighboring females are available, this newly escaped male may climb upon one of them and wait for mating to begin within. When such activity commences, it may then claw its way into the body of the mother concerned and assist the resident male in mating the females. During its period of waiting, this intruding male may occasionally puncture the body of the "host" mother to feed.

The young females of *dermestidarum,* unlike those of *tribolii,* need no conditioning period upon the adult beetles before attacking their eggs to begin feeding and physogastry.

SPECIMENS EXAMINED. In addition to the type series of *dybasi,* the following have been examined: *Species No. 1.* PANAMA: Barro Colorado Is., 2 ♀ ♀ from body of cerambycid.

Paracarophenax dybasi,[11] new species

DIAGNOSIS. This species is closest to *P. bambergensis* (Krczal), from which it differs in that the posterior margin of the posterior ventral plate is distinctly tripartite, in that all dorsal setae except laterals IV are stout and sparsely plumose, and because tarsus II and tarsus III possess two and one spinelike setae, respectively.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 257μ (257-279, $\bar{X} = 264.33$); width, 172μ (172-182, $\bar{X} = 178.00$); distance between anterior sternocoxal condyles III, 98μ (98-110, $\bar{X} = 105.00$).

Gnathosoma. Cheliceral bases widely separated, chelicerae large, bladelike, arcuate, converging posteriorly, then recurved abruptly anteriorly to enter buccal cavity.

Propodosoma. Dorsum. Large, hemispherical except for deep anterolateral excavations marking insertions of coxae I; anterior margin seemingly bending ventrally to cover gnathosoma anteriorly as well as dorsally; peritremes circular, dorsal, in anterior one-quarter, separated by less than twice the width of one; stigmatal openings circular, distinctly visible within peritremes; one pair of setae (stigmatals?) about one peritremal diameter in front of peritremal margin, short, bristlelike, directed anteriorly (position easily altered during mounting); pseudostigmatals stout, spiculate, blunt apically, anterior pair subequal in length to posterior pair and arising less

11. This species is named in honor of Henry S. Dybas, Associate Curator of Insects, Chicago Natural History Museum, who collected the type series.

than two areolar widths anterior to a line drawn between them; anterior pseudostigmatals about 43μ apart, posterior pseudostigmatals about 34μ laterad of respective anterior pseudostigmatals. *Venter.* Setae of anterior ventral plate nude, short, ventrals II about 31μ long, more than thrice length of ventrals I and distinctly mesad of them.

Hysterosoma. Dorsum. All setae of dorsum except laterals IV stout, spiculate, apically blunt; laterals IV flagellate; dorsals I well posterior to laterals I, 21μ (21-24, $\bar{X} = 22.80$) long, 68μ (68-72, $\bar{X} = 69.40$) apart; laterals I slightly longer than dorsals I, 26μ (25-26, $\bar{X} = 25.60$), closer to respective dorsals than dorsals are to each other; dorsals II as laterals I, 85μ (85-92, $\bar{X} = 90.00$) apart; dorsals III 18μ (15-19, $\bar{X} = 17.00$), 15μ (15-23, $\bar{X} = 20.60$) apart, laterals III usually slightly longer than dorsals III and posterolaterad of them by about their own length; dorsals IV 14μ (14-15) long, 20μ (20-24) apart; laterals IV 17μ (17-21, $\bar{X} = 18.30$) long, well anterolaterad of dorsals IV; setae of segment V well ventral, short, about 8 to 9μ. *Venter.* Posterior margin of posterior ventral plate shallowly tripartite; apodemes III vestigial, developed only at anterior sternocoxal condyles of coxae III; apodemes IV moderately developed, weakly sinuate, terminating well anterior to but on a longitudinal line with internal poststernals; all setae of posterior ventral plate short, nude, flagellate, about 11 to 23μ long; internal presternals arising in a straight line with external presternals and poststernals; external poststernals arising from center portion of tripartite ventral plate on (or nearly on) line drawn between posteromesal margins of coxal foramina IV; posterior margin of opisthosomal venter with distinct median excavation; opisthosomal ventrals 20μ (20-26, $\bar{X} = 22.80$) apart, 23μ (19-23, $\bar{X} = 21.20$) long, nude, flagellate.

Legs (all measurements in μ). *Length.* Leg I, 72 (69-72, $\bar{X} = 69.60$); leg II, 90 (90-94, $\bar{X} = 91.80$); leg III, 96 (94-104, $\bar{X} = 97.40$); leg IV, 110 (110-117, $\bar{X} = 112.00$). *Width.* Leg I, 24 (22-24, $\bar{X} = 23.60$); leg II, 17 (17-20, $\bar{X} = 18.21$); leg III, 14 (14-15, $\bar{X} = 14.20$); leg IV, 17 (15-17, $\bar{X} = 16.20$). *Segment lengths.* Tr I, 22 (22-24, $\bar{X} = 23.20$); tita I, 36 (34-36, $\bar{X} = 34.80$); tr II, 31 (26-31, $\bar{X} = 30.20$); ta II, 37 (33-37, $\bar{X} = 34.60$); ti III, 18 (17-18, $\bar{X} = 17.20$); ta III, ($\bar{X} = 33.00$); cx IV[12] 22 (22-24, $\bar{X} = 22.60$); tr IV, 42 (40-44, $\bar{X} = 42.40$); fege IV, 13 (12-13, $\bar{X} = 12.60$); ta

12. Distance measured between centers of anteroventral and posterodorsal sternocoxal condyles.

IV, 43 (41-43, $\bar{X} = 42.40$). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 14T + 5S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 7T + 1S; leg III: cx 1T, tr 2T, fege 3T, ti 4T, ta 7T; leg IV: cx 1T, tr 2T, fege 2T, ti 4T, ta 6T.

Seta *c* of trochanter I stout, blunt apically, seta *d* recurved; tibiotarsus I with two clavate and three setiform solenidia; basal clavate solenidium distinctly longer than and half the width of the distal; first seta basad of proximal clavate solenidium setiform, not lanceolate or flagellate; claw I with distinct mesal tooth on inner surface, otherwise without rounded basal dilation; thumb present, enlarged, bidentate; trochanter II, femurogenu II, and tibia II lacking spiniform setae, two such setae present on tarsus II, one on tarsus III; solenidium of tibia II elongate, weakly clavate, that of tarsus II less than half as long and twice as wide, both well distad of bases of their respective segments; tarsus IV lacking elongate, flagellate seta, slender, tapering evenly, ratio of femurogenu IV to tarsus IV 1.3.3 (1:3.2 to 1:3.6).

Distribution. Known only from the type locality.

TYPE MATERIAL. Female holotype and four female paratypes (nos. 1-4) from S. W. shore, Lake Clay (nr. Lake Placid), Highlands Co., Florida, June 14, 1955, H. S. Dybas, in debris under decaying fruit (berlese sample).

TYPE REPOSITORIES. Holotype and one paratype (no. 3) in the Chicago Natural History Museum, Chicago, Illinois. Two paratypes (nos. 1, 4) in the Snow Entomological Museum, The University of Kansas. One paratype (no. 2) in the U. S. National Museum, Washington, D. C.

Acarophenax Newstead & Duvall

(Figs. 43-44)

Acarophenax Newstead & Duvall, 1918, Royal Society Report No. 2 of Grain Pests (War) Committee, pp. 19-25, pl. VII and VIII. Type, *Acarophenax tribolii* Newstead & Duvall, 1918, by original designation.

This genus includes at least three forms, two of which are undescribed. All are probably egg parasites of various beetles. The cosmopolitan *A. tribolii* attacks the eggs and perhaps the adults of *Tribolium*, but it has been recorded from other tenebrionids (*Latheticus, Gnathocerus*) as well. One undescribed form seen by the author was taken from the nest of a flicker (*Colaptes*), in which it was perhaps parasitic upon a resident beetle. A second (undescribed) form is known from laboratory cultures of *Crypto-*

lestes ferrugineus (Steph.). *A. bambergensis* Krczal is parasitic upon nitidulids. This last named species as well as *A. dermestidarum* Rack, are placed in a new genus, *Paracarophenax* (p. 132).

Diagnosis. The females differ from all other genera in the family by the following combination of characters: anterior ventral plate with two pairs of setae, gnathosoma reduced and fused with the propodosomal arcula, concealed or nearly so, chelicerae stout and easily visible, legs II to IV lacking claws and possessing pretarsi which are nearly as long as the tarsi.

Description of Non-gravid Female. Length, 105 to 198μ; width, 66 to 128μ, width between anterior sternocoxal condyles of coxae III, 40 to 83μ; hysterosoma narrowly to broadly oval, posterior margin narrowly rounded; body weakly sclerotized, without coarse punctures.

Gnathosoma. Outlines indistinct, seemingly at least partially fused with subdorsal propodosomal arcula, not or scarcely visible in dorsal aspect; palpi fused, indistinct; setation reduced, consisting of one pair anteriorly or anterodorsally, one pair of ventral palpal setae and sometimes a pair of palpal solenidia, and one or two pairs of lateroventrals, the most basal of which may be the displaced internal ventrals I; chelicerae stout, styliform, recurved basally, easily visible; large spindle-shaped pharyngeal-esophageal pump visible internally, extending posteriorly to anterior mesal portions of coxae II, salivary ducts distinct dorsal to this pump.

Propodosoma. Dorsum. Dorsal plate broad, shieldlike, at least partially projecting over gnathosomal region anteriorly, posterior margin overlapping first hysterosomal segment; internal U-shaped apodeme of arcula prominent dorsally, its arms continuous anteriorly with peritremes; peritremes in "shoulders," directed anteriorly or turning ventrally, enclosing gnathosoma laterally; internal atria prominent, dorsal, drop-shaped or circular; pseudostigmata lacking; two or three pairs of propodosomal setae, if three, anterior pair small, indistinct. *Venter.* Anterior ventral plate with two pairs of setae, ventrites I and II each with a single pair; ventral externals I lacking; coxa I (as seen in ventral aspect) attached at a right angle to longitudinal axis of body or nearly so; apodemes II very strong, straight, incomplete medially or nearly so, making angle of about 45 degrees or less with anterior median apodeme, the latter well developed; posterior marginal apodemes well defined, nearly complete; pleated conjunctival band between propodosoma and hysterosoma indistinct.

Hysterosoma. Dorsum. First segment entire, overlapped anteriorly by propodosoma, fourth segment with one (rarely) or two pairs of setae, completely enclosing fifth segment in dorsal aspect; fifth segment much reduced, sometimes vestigial, bearing one pair of setae or none; vulva apical or apicoventral; internal hysterosomal structures absent or at least indistinct. *Venter.* Posterior ventral plate entire, bearing three or five pairs of setae; hind margin of posterior ventral plate broadly rounded or shallowly trilobate; second axillaries well mesad of and slightly anterior to legs IV; external presternals (may be internal poststernals) lacking; external poststernals arising medially or absent; apodemes III rather poorly developed, absent or short and straight and directed anteromedially; apodemes IV strong, straight, incomplete, arising at anterior sternocoxal condyles of coxae IV and proceeding anteromedially; apodemes V lacking; posterior median apodeme absent or reduced to a short line posterior to mesal terminations of apodemes IV; band of opisthosomal conjunctival pleats indistinct; opisthosoma short, distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV; opisthosomal venter entire, bearing a single pair of setae.

Legs. Well developed and long, margins of segments often with well sclerotized areas of varying thickness; leg I four-segmented, distinctly wider than leg II and (excluding pretarsus) about as long; tibiotarsus I subelliptical, distinctly wider than other segments of leg; large, rounded sclerotized spot near outer margin of tibiotarsus I present midway between base and claw, this spot appearing internal rather than on dorsal surface; claw I single, stout, dilated basally, sessile, sometimes deformed, furnished with a stout, spine-like thumb, or thumb vestigial; trochanter I with two or three setae, seta *c* aciculate or absent, if present not reaching tibiotarsal sensory spot; trochanter II with three setae, femurogenu II with one or three; trochanter III with one or two setae, femurogenu III with one or two; tarsus II with five or six setae and a sensory peg, tarsus III with five setae; solenidium of tarsus II in basal one-half; solenidia of tibiae II and III lacking; pretarsi of legs II to IV elongate, nearly as long as tarsi; claws II to IV lacking, pulvilli II to IV well developed; coxa III long, triangular; coxa IV subcordate, distinctly mesad of coxa III; femurogenu IV with one seta, tarsus IV moderately long, tapering evenly, ratio of femurogenu IV to tarsus IV approximately 1:2.2 to 1:3.1.

Description of Gravid Female.[13] Gnathosoma as described for non-gravid female but entire hysterosoma becoming greatly physogastric, globular.

Description of Male.[13] Length, similar to female; more angulate posteriorly than female and flattened dorsoventrally in life; opisthosoma not greatly modified to form connate or trapezoidal copulatory structure.

Gnathosoma. Reduced but present, hidden within propodosoma.

Hysterosoma. Venter. Apodemes III, IV, and V well developed, the first two nearly complete medially; opisthosoma bearing large, subcircular "genital plate," this with two pairs of "minute suckers"; apicoventrally, a pair of long setae and "another pair of suckers."

Legs. All legs five-segmented, legs II to IV shorter and stouter than those of female; tarsus I less incrassate, claw I smaller than in female; legs IV not tonglike or greatly modified for clasping, similar to legs III but distinctly shorter.

Habits. Information is available only on the habits of *A. tribolii.* This species is found upon the bodies of *Tribolium confusum* Duval and other grain-inhabiting forms, principally beneath the elytra. In beetle cultures nearly every specimen may become infested with as many as thirty but more commonly ten to twelve female mites. Newstead and Duvall state that they "appear to be able to attack their hosts where the cuticle is thin between the joints, but most of them . . . where the large area of soft cuticle . . . offers little resistance to their minute, piercing and sucking jaws." In referring to a closely related form, *Paracarophenax dermestidarum,* Rack (1959), states that a similar mite-adult beetle association is purely phoretic. Since Newstead and Duvall failed to find gravid females upon the adult beetles, and since they report that the presence of the mites did not harm the adult host, it is probable that the same situation obtains in *A. tribolii.*

Phoretic females drop from the host beetle during the latter's oviposition and seek out an egg. Attaching to it, they begin to suck out its contents, resulting in its collapse. As they feed, physogastry commences, the entire female hysterosoma rapidly becoming enlarged and spherical, finally reaching 250 to 300μ in diameter. As enlargement progresses, the capability of the female to move is lost. Newstead and Duvall, referring to the female, state that "on the

13. Specimens of these stages not seen, information taken from original description of *A. tribolii* N. and D. Quotations are from original description to which the reader is referred for more detail.

third day (after attachment to the egg) she dies and the young females emerge through a hole which corresponds in position to the genital orifice but which they enlarge for themselves." As in *Pyemotes* and *Trochometridium* the definitive immature stages are thus lost and the preimaginal period greatly shortened. The number of young varies from four to fifteen, depending upon the size of the physogastric mother. One of these is usually a male. Newstead and Duvall report several instances in which a male was lacking but never found more than a single male. Presumably mating occurs within the body of the mother before hysterosomal breakdown and accompanying birth since the male is found (usually dead) only within or immediately outside of the maternal body.

It was found that the newly born females did not immediately parasitize eggs offered to them, a fact which led Newstead and Duvall to infer that a conditioning period upon the adult beetle is necessary for "proper development." The fate of young females attaching themselves to males or to very old female beetles is not known, although Newstead and Duvall report that many finally perish upon the beetles.

SPECIMENS EXAMINED. Three species, including *tribolii,* from many parts of the United States, and India, taken from the following situations and hosts: rye mill, waste mill material, debris in nest of *Colaptes cafer* (Gmelin) (Aves, Piciformes), *Tribolium confusum* Duval, *Gnathocerus cornutus* (Fabricius), *Latheticus oryzae* Waterh., *Cryptolestes ferrugineus* (Steph.), (all Coleoptera).

Adactylidium, new genus

(Figs. 48-50)

Type, *Adactylidium beeri,* new species.

This genus includes *A. nicolae* (Krczal) and three previously undescribed species taken from various Thysanoptera in Michigan, New York, Florida, and Colombia (S. A.). Morphologically, it is most closely related to *Acarophenax,* but differs in that it lacks claws I, in that apodemes II are weakly arcuate and join the anterior median apodeme at an angle of nearly 90 degrees, because apodemes III are complete medially, and in exhibiting a reduced number of setae on certain structures (anterior ventral plate with one or two pairs, posterior ventral plate with only four pairs, tarsus II with five setae plus solenidium, tarsus III with four).

Of all the Acarophenacinae, members of this genus are alone in

their association with insects other than beetles. As with other members of the subfamily, the species seem to be parasites of their hosts. Only the young, non-gravid females are known.

Diagnosis. Females are distinct from those of all other genera in the family in possessing the following combination of characters: small size (length, 140 to 170μ), oval; leg I four-segmented, claws lacking on all legs; anterior ventral plate with one or two pairs of setae; pseudostigmata lacking.

Description of Non-gravid Female. Length, 145 to 170μ; width, approximately 90 to 110μ; width between anterior sternocoxal condyles of coxa III approximately 44 to 68μ; hysterosoma oval, its posterior margin usually narrowly rounded; dorsum with or without coarse punctae.

Gnathosoma. Outlines indistinct, completely enclosed within propodosoma, not visible in dorsal aspect; palps fused, indistinct; setae of gnathosomal region reduced to one pair or none, if present, then directed anteriorly or anteroventrally; chelicera recurved, stout and needlelike, or stout basally and becoming indistinct apically; elongate, spindle-shaped pharyngeal-esophageal pump distinct or not, if distinct then extending posteriorly to anterior-mesal portions of coxa II, salivary ducts usually distinct dorsal to this pump.

Propodosoma. Dorsum. Broadly trapezoidal, anterior margin indistinct but probably continuing ventrad to completely or nearly completely envelop gnathosoma anteriorly; posterior margin overlapping first hysterosomal segment; U-shaped apodemes of arcula prominent, continuous anteriorly with peritremes; peritremes in "shoulders," circular, directed anteriorly or anteroventrally, bounding gnathosoma laterally; internal atria usually prominent, drop-shaped; pseudostigmata lacking; two or three pairs of propodosomal setae, anterior pair, if present, tiny, often indistinct, arising mesad of peritremes and appearing to be on gnathosoma. *Venter.* Anterior ventral plate probably with two pairs of setae, anterior pair sometimes not visible; coxa I as seen in ventral aspect attached obliquely to longitudinal axis of body; apodemes II strong, arcuate, complete medially or nearly so, making nearly a right angle with anterior median apodeme at point of intersection; anterior median apodeme well developed, its anterior portion appearing to extend into gnathosomal region; posterior marginal apodemes well defined, incomplete medially; pleated conjunctival band present dorsally between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment entire, overlapped anteriorly by propodosoma, bearing two pairs of setae; fourth segment with two pairs of setae, fifth segment much reduced, lacking setae, completely enclosed dorsally and laterally by fourth, usually visible only ventrally as an arcuate line; vulva apical. *Venter.* Posterior ventral plate entire, bearing four pairs of setae, external presternals and one pair of poststernals missing; hind margin of posterior ventral plate straight (could not be determined for one species); first axillary moderately mesad of anterior condyles of third coxa; second axillary seta arising from or slightly behind apodeme IV, well mesad of anterior sternocoxal condyle III; external presternal and internal poststernal setae lacking; apodemes III well developed, complete, arcuate, curving into posterior median apodeme; apodemes IV strong, slightly arcuate, incomplete medially, arising at anterior condyles of coxae IV, in general paralleling apodemes III; apodemes V absent, an integumental fold between the posteromesal margins of coxae IV sometimes distinct and appearing apodeme-like; posterior median apodeme weakly to strongly developed, complete or intermittent, extending well behind line drawn between anterior sternocoxal condyles of coxae IV; band of opisthosomal conjunctival pleats well developed, usually distinctly visible beneath opisthosomal venter; opisthosoma short, distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV; opisthosomal venter bearing a single pair of setae, its posterior margin entire or deeply cleft.

Legs. Well developed, of moderate length, margins of segments often with well sclerotized area of varying thickness; leg I four-segmented, distinctly narrower than leg II; tibiotarsus I elongate, sinuate or subrectangulate, not wider than other segments of leg; mediolateral sclerotized area near outer margin of tibiotarsus I lacking; claw I lacking; most basal seta of tibiotarsus I short, modified bladelike or clavate; trochanter I with three small setae, seta *c* unmodified, not reaching base of tibiotarsus I; trochanter II with three setae, femurogenu II with three; trochanter III with two setae, femurogenu III with two; solenidia of tibiae II and III lacking; tarsus II with five setae and a solenidium; tarsus III with four setae (one of these setae on tarsus II and two setae on tarsus IV arising at base of pretarsus, difficult to see); pretarsi II to IV moderately long, excluding pulvilli about half as long as tarsi; claws II to IV lacking, pulvilli well developed; coxa III long-triangular; coxa IV subcordate or short-triangular, not distinctly mesad of

coxa III; femurogenu IV with one seta; tarsus IV about as long as III, tapering evenly; ratio of femurogenu IV to tarsus IV about 1:2.5 to 1:3.0; tarsus IV bearing one greatly elongate flagellate seta.

Habits. No information concerning the habits of these forms is known. On morphological and phylogenetic grounds one may infer that they are parasites, probably either of the eggs or other stages, of various species of thrips, and that the females become greatly physogastric when gravid.

Specimens Examined. In addition to the types species, the following are known: *Species No. 1;* Colombia: Intercepted at Washington, D. C., 5 ♀ ♀ from thrips on *Cattleya* sp. *Species No. 2;* Florida: Welaka, 1 ♀ on *Elaphrothrips tuberculatus* (Hood);[14] New York: *Ithaca,* 3 ♀ ♀ on *Megalothrips spinosus* [14] Hood.

Adactylidium beeri,[15] new species

Diagnosis. Very close to *A. nicolae* (Krczal), differing chiefly in that the single clavate solenidium of tibiotarsus I is in the apical half of the segment, in that the anterior setae of the anterior ventral plate (see Krczal, 1959b, p. 554) are not visible and perhaps lacking, and because the setae of segment III are subequally spaced.

Description of Non-gravid Female. Length, 129μ (128-142, $\bar{X} = 132.16$); width, 89μ (89-96); distance between anterior sternocoxal condyles of coxae III, 44μ (44-46, $\bar{X} = 45.00$); body broadly oval.

Gnathosoma. Chelicerae stoutly aciculate, converging posteriorly, then recurved abruptly anteriorly to enter buccal cavity; anterior setae of gnathosomal region lacking.

Propodosoma. Dorsum. Dorsal propodosomal plate not coarsely punctate, extending posteriorly distinctly beyond line drawn between posterior margins of coxal foramina II; both pairs of pseudostigmatals nude, finely flagellate, the inner pair approximately 15μ anteromesad of the lateral pair; distance between inner pseudostigmatals 37μ (37-39); internal U-shaped apodemes of arcula bandlike; peritremes opening anterolaterally, not or only slightly directed ventrad. *Venter.* Apodemes II rather evenly and shallowly arcuate, complete medially; ventral setae I not visible, ventrals II short, nude, flagellate.

14. Det. J. D. Hood, Cornell University, Ithaca, N. Y.
15. Named for Dr. Robert E. Beer, The University of Kansas.

Hysterosoma. Dorsum. Integument not coarsely punctate; setae of terga I to III long, nude, finely flagellate,[16] setae of tergum IV short, bladelike; dorsals I less than diameter of areolus anterior to laterals, approximately 16 to 21μ long, 37μ (37-43, $\bar{X} = 40.80$) apart; laterals I about as long as dorsals I, nearly twice as close to respective dorsals as dorsals to each other; dorsals II subequal to dorsals I in length, 52μ (48-54, $\bar{X} = 52.00$) apart; all setae of third tergum similar to those of dorsals I and II in length, dorsals III 17μ (17-22, $\bar{X} = 19.00$) apart, laterals about two areolar diameters behind line drawn through their areoli, and well laterad of them; setae of tergum IV terminal, arising posteroventrally, directed posteriorly and posterolaterally, dorsals and laterals subequal in length and shape, seven to eight μ long, spaced subequally across segment or nearly so. *Venter.* Apodemes III stout, broadly arcuate; all sternal setae short, approximately eight to fourteen μ, nude, flagellate; posterior margin of posterior ventral plate not or shallowly emarginate; internal presternals arising approximately eight μ laterad of posterior median apodeme, poststernals slightly more mesad; opisthosomal sternals nude, flagellate, short, approximately seven to eleven μ, on longitudinal line with internal presternals; posterior margin of opisthosomal sternum deeply emarginate.

Legs (all measurements in μ). *Length.* Leg I, 33 (32-34, $\bar{X} = 33.00$); leg II, 46 (46-47, $\bar{X} = 46.33$); leg III, 50 (47-52, $\bar{X} = 49.66$); leg IV, 46 (46-52, $\bar{X} = 48.50$). *Width.* Leg I, 8 (7-8, $\bar{X} = 7.83$); leg II, 13 (10-13, $\bar{X} = 11.66$); leg III, 9 (8-9, $\bar{X} = 8.83$); leg IV, 8 (8-9, $\bar{X} = 8.16$). *Segment lengths.* Tr I, 9 (8-10, $\bar{X} = 9.00$); tita I, 19 (18-20, $\bar{X} = 18.33$); tr II, 14 (14-15, $\bar{X} = 14.83$); ta II, 18 (15-19, $\bar{X} = 17.00$); ti III, 9 ($\bar{X} = 9.00$); ta III 19 (18-19, $\bar{X} = 18.50$); cx IV,[17] 14 (13-17, $\bar{X} = 14.50$); tr IV, 15 (15-19, $\bar{X} = 16.66$); fege IV, 5 (5-6, $\bar{X} = 5.20$); ta IV 18 (18-19, $\bar{X} = 18.83$). *Setation.* Leg I: cx 0T, tr 3T, fege 4T, tita 11T + 5S; leg II: cx 0T, tr 3T, fege 3T, ti 4T, ta 5T + 1S; leg III: cx 0T, tr 2T, fege 1T, ti 4T, ta 4T; leg IV: cx 0T, tr 1T, fege 1T, ti 4T, ta (? 3T).[18]

Setae *c* and *d* of trochanter I short, setiform; tibiotarsus I subelliptical, not sinuate, its most basal seta short (often difficult to see) with one median clavate and four apical-subapical rodlike solenidia;

16. Because of the extreme fineness of the apices of these setae, it was not possible to determine their lengths with enough accuracy to give exact measurements. Approximations of their lengths are given instead.

17. Measured between anterior and posterior sternocoxal condyles.

18. Presence of apical setae not ascertained.

solenidium of tarsus II short and rodlike, as broad as base of broadest sensory seta of tarsus II.

Distribution. Known only from the type locality.

Type Material. Female holotype and five female paratypes (nos. 1 to 5) from the University of Michigan Biological Station, Cheboygan Co., Michigan, August 2, 1958, R. E. Beer, from thorax of Thysanoptera (host No. M-58-5).

Type Repositories. Holotype and three paratypes (nos. 1 to 3) in the Snow Entomological Museum at The University of Kansas; paratype no. 4 in the U. S. National Museum; paratype no. 5 to the Zoologisches Institut, Universität Erlangen, Erlangen, Germany.

Pygmephorinae, new subfamily

Description of Non-gravid Female. Small to moderately sized mites, 150 to 600μ long; shape variable, usually elliptical to oval, rarely circular; posterior margin of hysterosoma evenly rounded or truncate; integument usually moderately, often heavily sclerotized, integumental "pebblings" or other engravings present or absent.

Gnathosoma. Always free, directed anteroventrally, ventrally, or posteroventrally, never largely or completely hidden within the propodosoma; palps free and movable; chelicerae usually small, indistinct, rarely enlarged and distinct.

Propodosoma. Dorsum. Always entire, pseudostigmata present; one to three pairs of dorsal propodosomal setae; anterior margin of first hysterosomal tergum usually overlapping propodosoma to varying degrees, occasionally entirely; esophageal "finned structures" present or absent. *Venter.* Anterior ventral plate with four to six pairs of setae.

Hysterosoma. Four to five visible segments, segment V often enclosed dorsally but never posteroventrally by tergum IV; segment V with two or three pairs of setae; posterior portion of vaginal wall sclerotized or enclosed in enlarged, elliptical to globose pumplike structures or not; at least one genital sclerite present, shape variable; opisthosoma not distinctly shorter than distance between anterior margin of coxa III and posterior margin of coxa IV, or if so, then body circular; opisthosomal venter lacking setae.

Legs. Leg I four-segmented; coxa I, as seen from beneath, articulated at a right angle to longitudinal axis of body or (usually) distinctly obliquely; claws sometimes absent on leg I or leg IV, or

both, always present on II and III; trochanter I with three to four setae, seta *c* setiform, stout and rodlike, spatulate apically, or membranous and blade or hooklike; pinnacula present or absent; coxa IV quadrate to rectangulate.

Key to the Tribes of the Subfamily Pygmephorinae (Females)

1(*a*). With three pairs of propodosomal dorsals; four to six pairs of anterior sternals; trochanter I with three or four setae; claw I, if present, sessile
Pygmephorini, new tribe, p. 148

1(*b*). With one or two pairs of propodosomal dorsals; four pairs of anterior sternals; trochanter I with three setae; claw I, if present, usually more or less pedicellate....2

2(*a*). Seta *c* of trochanter I setiform; one pair of propodosomal dorsals, or, if two, second pair not visible except under very high magnification; hysterosomal segment V usually with two pairs of setae
Microdispini, new tribe, p. 164

2(*b*). Seta *c* of trochanter I semimembranous, bladelike, the apical portion usually proflexed; one (rarely) or two pairs of propodosomal dorsals; segment V usually with three pairs of setae
Neopygmephorini, new tribe, p. 196

Pygmephorini, new tribe

This tribe includes three genera: *Pediculaster* Vitzthum, 1931, *Pygmephorus* Kramer, 1877, and *Microdispodides* Vitzthum, 1914. Its members are considered to be closely related to and perhaps directly descended from members of the genus *Siteroptes*. Females are easily distinguished from those of the remaining two tribes of the Pygmephorinae in possessing three pairs of propodosomal dorsals as well as in other characters outlined in the description below.

DESCRIPTION OF NON-GRAVID FEMALE. Striae absent on most lateral portions of posterior ventral plate.

Gnathosoma. Quadrate or longer than wide; palps never greatly elongate, fitted for piercing.

Propodosoma. Dorsum. With three pairs of setae; peritremes dorsal, contiguous or widely separated, cylindrical, guttate, or circular; two esophageal "finned" structures present. *Venter.* Anterior ventral plate with four to (usually) six pairs of setae; external ventrals I furcate or not.

Hysterosoma. Dorsum. First hysterosomal tergum never covering more than posterior half of propodosoma; segment V with three pairs of setae; posterior portion of vaginal wall often enclosed in elliptical or globose pumplike structure; posterior genital sclerite usually elongate, never broadly triangular or flaplike. *Venter.* Apodemes V present or absent.

Legs. Leg I articulated obliquely or at a right angle to the longitudinal axis of body; size variable; claw I rarely absent, if present, sessile; mediolateral sclerotized area of tibiotarsus I present or absent; trochanter I with three or (usually) four setae, seta *c* short, membranous, bladelike, often hooked, or elongate, stout-setiform, blunt or spatulate apically; pinnacula of tibiotarsus I absent.

Key to the Genera of the Tribe Pygmephorini (Females)

1(*a*). Seta *c* of trochanter I straight and stout, obtuse or spatulate apically ..... *Pediculaster*, p. 149

1(*b*). Seta *c* of trochanter I short, semimembranous, more or less bladelike and proflexed apically 2

2(*a*). Claws I and IV lacking; dorsum of body with scalelike integumental engravings ..... *Microdispodides*, p. 159

2(*b*). Claws I and IV present; dorsum of body lacking scalelike integumental engravings ..... *Pygmephorus*, p. 156

Pediculaster Vitzthum

This genus is closely related to certain *Siteroptes* and *Pygmephorus*. It resembles the former in general body conformation, in that coxae I arise nearly at a right angle to the longitudinal axis of the body, in possessing three pairs of propodosomal dorsals, in that trochanter I bears four setae, and in that the stigmata are guttate or elliptical and contiguous or nearly so. It differs from *Siteroptes* and resembles *Pygmephorus* in that tibia and tarsus I are fused, in that claw I is stout and sessile, and because claws II and III are cleft and dilated basally. It also differs from *Siteroptes* in that many, if not all, forms are phoretic upon various Diptera.

Specific relationships within the group are seemingly complex. The author has examined at least seven species.

Only the females of *Pediculaster* are known.

Diagnosis. Females are distinguished from those of other genera in the family by the following combination of characters: leg I with four segments, claw I sessile and often deformed, seta *c* of trochanter I stout and straight, blunt or spatulate apically, propodosoma with three pairs of dorsals.

Description of Non-gravid Female. Length, 200 to 480μ; width, 95 to 290μ; width between anterior sternocoxal condyles of leg III 65 to 240μ; hysterosoma broadly to narrowly elliptical; integument pale and weakly sclerotized to yellow-brown and heavily sclerotized, lacking scalelike or "pebbled" integumental engravings; body usually with large punctae.

Gnathosoma. Normally directed ventrally, shape quadrate to rectangular; palps with large apical teeth; chelicerae distinct, aciculate; esophageal-pharyngeal pump absent but esophageal "finned" structures usually distinct.

Propodosoma. Dorsum. Distinct dorsal sclerite present, enlarged posteriorly, rounded or falcate at points of greatest width; anterior portion prolonged hoodlike over gnathosoma, circumgnathosomal foramen anteroventrad, its lateral margins only moderately sclerotized; posterior margin covered by anterior margin of first hysterosomal tergum or these two sclerites meeting but not overlapping; pseudostigmata located in posterior third to fifth of dorsal plate; three pairs of propodosomal dorsals; peritremes dorsal and median, usually contiguous or nearly so, diverging, guttate, campanulate, or elliptical, often septate; two esophageal "finned" structures visible. *Venter.* Anterior ventral plate with four to (usually) six pairs of setae, if five pairs then ventrites II with only two pairs; external ventrals I not bifurcate; ventral medials II, if present, usually much closer to externals II than to internals II; coxa I articulating at nearly a right angle to the longitudinal axis of body or (rarely) coxa I articulating obliquely; apodemes II distinct, straight or bending posteriorly near anterior median suture, usually complete, if straight then making angle of more than 45 degrees with anterior median apodeme; secondary transverse suture absent; posterior marginal apodemes well developed; pleated conjunctival band between propodosoma and hysterosoma not distinct.

Hysterosoma. Dorsum. Fifth dorsal segment well developed but usually completely enclosed by fourth in dorsal aspect; vulva apicoventral; vagina heavily sclerotized apically or not, surrounded by globose to elliptical pumplike enlargements or not; anterior genital sclerite separable from other genital sclerites or not, but if so, then its anteriormost point well posterior to line drawn between the posterior margins of coxae IV; posterior genital sclerite variable in shape but not broadly flaplike. *Venter.* Posterior ventral plate entire or (rarely) divided by a single transverse line between the centers of coxae III, the two plates thus formed contiguous and not overlapping; posterior ventral plate with four to six pairs of setae; hind margin of posterior ventral plate tripartite, trilobed, or straight; second axillaries present or absent; external presternals well behind and usually barely laterad of internal presternals, arising from or only slightly anterior to apodemes IV; position of external poststernals variable; apodemes III and IV well developed

or (rarely) lacking, if present at least apodemes III meeting posterior median apodeme; apodemes III bending posteriorly at the sides to join anterior sternocoxal condyles III; apodemes IV arising laterally between coxae III and IV, meeting posterior sternocoxal condyle of III; apodemes V present or absent, if present then joining posterior median apodeme; band of distinct opisthosomal conjunctival pleats lacking; opisthosoma long, always longer than distance between anterior margin of coxa III and posterior margin of coxa IV.

Legs. All legs well developed and bearing claws; leg I four-segmented, always distinctly wider and usually much longer than leg II; tibiotarsus I quadrate to rectangulate, tapering, not or barely wider than other segments of leg; pinnacula lacking; mediolateral sclerotized plate of tibiotarsus I absent or poorly developed; claw I stout, sessile, dilated basally or not, bearing thumb or not; trochanter I with four setae; seta *c* straight and stout, nude, not flagellate, bluntly pointed or spatulate apically, rarely reaching middle of femurogenu; tarsi II and III each bearing six tactiles; solenidia of tibiae II and III present; claws II and III simple or with cleft or basal dilation; claw IV simple, usually not much smaller than those of II and III; pulvilli II to IV trumpet-shaped, always longer than claw; coxa III triangular or subcordate in inner ventral aspect; coxa IV subquadrate to rectangulate, not constricted near base, not bulbose; tarsus IV short to moderately elongate, not evenly attenuate from base to apex; ratio of femurogenu IV to tarsus IV approximately 1:1.6 to 1:4.1. *Description of gravid female.* As above but entire hysterosoma becoming physogastric, globular.

Key to the Subgenera of *Pediculaster* (Females)

1(*a*). Posterior ventral plate entire..... *Pediculaster sensu stricto*, p. 154
(*b*). Posterior ventral plate divided transversely between coxae III *Acarothorectes*, p. 151

Acarothorectes, new subgenus

(Figs. 54-56)

Type, *Pediculaster* (*Acarothorectes*) *curculionium*, new species.

This subgenus is established to accommodate a single species which differs markedly from the remaining forms within the genus. In addition to the morphological differences mentioned below, the type series was taken from the body of a curculionid, an unusual host for forms of *Pedicaster*.

DESCRIPTION OF NON-GRAVID FEMALE. Agrees with the description of the genus except for the following: hysterosoma narrowly elliptical, markedly elongate; integument moderately sclerotized, coarsely punctate.

Gnathosoma. Small, rectangulate.

Propodosoma. Dorsum. Dorsal sclerite elongate, with distinct median longitudinal keel from which arise the peritremes, pseudostigmata, stigmatal, and anterior pseudostigmatal setae; laterad of keel on each side, a concavity which receives the clavola of the pseudostigmata; peritremes campanulate, diverging nearly 180 degrees; esophageal "finned" structures characteristic, the anterior much larger and more conspicuous than the posterior, the fins much more distinct and thicker than those found in other members of the genus. *Venter.* Anterior ventral plate with five pairs of setae; coxa I articulating at nearly a right angle to longitudinal axis of body; apodemes II straight, incomplete medially; anterior median apodeme complete, becoming increasingly weaker posteriorly.

Hysterosoma. Dorsum. Vagina not heavily sclerotized apically, not surrounded by globose to elliptical pumplike enlargement, but a heavily sclerotized ringlike structure present. *Venter.* Posterior ventral plate divided by a single transverse line between the centers of coxae III, the two plates thus formed contiguous and not overlapping; posterior ventral plate with but four pairs of setae; hind margin of ventral plate with single, large median lobe; internal presternals displaced anteriorly, arising at least two setal lengths anterior to external presternals, well mesad of latter; external poststernals arising less than three areolar widths behind line drawn between posterior margins of coxal foramina IV; apodemes III to V absent; posterior median apodeme short, weak.

Legs. Leg I much wider and distinctly shorter than leg II; tibiotarsus I quadrate, tapering, not wider than femurogenu I; mediolateral sclerotized plate absent; claw I with irregular basal dilation, thumb small; seta *c* spatulate apically;[19] claws II and III with elongate ventral thickenings which terminate subapically, possibly in a tooth; claws IV simple, stouter than claws II and III; pretarsus IV nearly one third total length of tarsus IV; coxa IV short, subquadrate, slightly wider than long; tarsus IV quadrate, ratio of femurogenu IV to tarsus IV approximately 1:1.6.

19. In all mounted specimens of the type series, legs I are twisted so that claw I turns outward rather than inward, resulting in a mesal displacement of certain setae including those of the trochanter. The normal position of legs I therefore probably differs somewhat from closely related forms.

HABITS. Nothing is known of the habits of this mite.

Pediculaster (*Acarothorestes*) *curculionium*, new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 229μ (223-290, $\bar{X} = 249.67$); width, 96μ (83-110, $\bar{X} = 100.17$); distance between anterior sternocoxal condyles of coxae III, 59μ (58-79, $\bar{X} = 65.17$); punctae covering entire body, including tips of tarsi.

Gnathosoma. Small, length [20] (19-26); width [20] (15-17); external dorsals lacking; solenidium 2 small, slightly shorter than solenidium 1, not capitate; distance between first and second palpal setae about 5μ.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets 9μ (9-11, $\bar{X} = 10.66$); all propodosomal setae stout, spiculate; stigmatals only three to five μ apart, approximately 25 to 30μ long, subequal in size to posterior pseudostigmatals; anterior pseudostigmatals smaller, arising about one areolar diameter posterolateral of stigmatals; posterior pseudostigmatals arising nearly directly laterad of pseudostigmata, about 25 to 30μ apart. *Venter.* Five pairs of short, nude, flagellate setae, the two pairs on ventrites II subequal in size, approximately 16 to 21μ, distinctly longer than setae of ventrites I; internal ventrals II only slightly closer to external ventrals II than to anterior median apodeme; apodemes II straight, strongest laterally, becoming progressively weaker toward the center, incomplete medially, making angle of about 60 degrees with anterior median apodeme.

Hysterosoma. Dorsum. All dorsal setae except laterals III, dorsals IV, and all setae of segment V stout, spiculate, their apices blunt or bluntly pointed; dorsals I (21-25, $\bar{X} = 23.60$) long, 29μ (28-31, $\bar{X} = 29.67$) apart; laterals I about two to four areolar widths anterior to line drawn between dorsals I, 28μ (28-33, $\bar{X} = 29.50$) long, distinctly closer to respective dorsals than dorsals to each other; dorsals II 22μ (17-23, $\bar{X} = 21.00$) long, 42μ (41-45, $\bar{X} = 42.17$) apart; dorsals III 25μ (23-26, $\bar{X} = 24.83$) long, as far apart as dorsals II; laterals III bristlelike, 7μ (5-7, $\bar{X} = 6.50$) long, arising about one dorsal areolar width laterad of respective dorsals; dorsals IV similar to laterals III in size and conformation, well behind and only slightly mesad of laterals IV, 26μ (25-31, $\bar{X} = 27.67$) apart; laterals IV 25μ (13-25, $\bar{X} = 15.83$) long; internal and external caudals I subequal in size, bristlelike, about four μ long, external caudals II

20. These measurements of the holotype not possible.

bristlelike but longer, about 16μ. *Venter.* All setae of posterior ventral plate short, nude, flagellate, approximately 10 to 15μ long; internal presternals nearly the length of coxa III anterior to coxa III.

Legs (all measurements in μ). *Length.* Leg I, 56 (55-63, $\bar{X} = 58.50$); leg II, 75 (74-80, $\bar{X} = 75.67$); leg III, 74 (74-80, $\bar{X} = 76.50$); leg IV, 58 (58-68, $\bar{X} = 61.00$). *Width.* Leg I, 23 (16-24, $\bar{X} = 21.83$); leg II, 14 (11-15, $\bar{X} = 13.16$); leg III, 11 (8-12, $\bar{X} = 10.17$); leg IV, 17 (14-19, $\bar{X} = 16.17$). *Segment lengths.* Tr I, 25 (24-28, $\bar{X} = 25.17$); tita I, 23 (23-26, $\bar{X} = 24.83$); tr II, 19 (18-20, $\bar{X} = 18.67$); ta II, 31 (31-35, $\bar{X} = 32.56$); ti III, 14 (14-17, $\bar{X} = 15.00$); ta III, 30 (28-33, $\bar{X} = 30.33$); cx IV, 18 (18-22, $\bar{X} = 19.33$); tr IV, 14 (14-19, $\bar{X} = 16.50$); fege IV, 9 (8-9, $\bar{X} = 8.67$); ta IV, 14 (14-17, $\bar{X} = 15.00$). *Setation.* Leg I: cx 0T, tr 3T + 1 specialized, fege 4T, tita 12T + 9S; leg II: cx 1T, tr 3T, fege 1T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tibiotarsus I with five rodlike and four short, stout, solenidia, the latter all in apical third of the segment; claw I sharply bent, a conspicuous tubercle on its inner margin; thumb stout but short; solenidia of tibiae II and III small, clavate, sub-basal; solenidium of tarsus II also sub-basal, short and stout, approximately 4.5 x 3μ; tarsi II and III each constricted suddenly into elongate pedicel nearly one-third total length of tarsus; solenidium of tibia IV short, clavate, sub-basal; tarsus IV with three greatly elongated apical setae, the external distinctly longer than the two internals.

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Female holotype and five female paratypes (nos. 1 to 5) from Palmira-Valle, Colombia (Let.), May 14, 1946, from B. Losada S., on *Copturomimus* sp. (Curculionidae).

TYPE REPOSITORIES. Holotype and three paratypes (nos. 2, 3, 5) in the U. S. National Museum, Washington, D. C. One paratype (no. 1) in the Snow Entomological Museum, The University of Kansas. One paratype (no. 4) in the Zoologisches Institut, Universität Erlangen, Erlangen, Germany.

Subgenus *Pediculaster, sensu stricto*

(Figs. 57-58)

Pediculaster Vitzthum, 1931, Memoires du Musée Royal D'Histoire Naturelle De Belgique, Hors Serie—Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises, 3 (5):36, Acarina. Type, *Pygmephorus mesembrinae* R. Canestrini, 1880, by original designation.

Description of Non-gravid Female. *Propodosoma. Dorsum.* "Fins" of esophageal "finned" structure fine, often difficult to see.

Hysterosoma. Venter. Posterior ventral plate entire, not divided transversely between coxae III; posterior ventral plate with five or six pairs of setae; apodemes III and IV always present.

Species thought to belong in *Pediculaster, s. str.:*

americanus (Banks, 1905) (*Pygmephorus*)
americanus var. *socotrensis* (Hirst, 1921) (*Pygmephorus*)
heliocopridis (Vitzthum, 1931) (*Pediculoides*)
manicatus (Berlese, 1904) (*Pygmephorus*)
mesembrinae (Canestrini, 1880) (*Pygmephorus*)
?*wichmanni* (Vitzthum, 1923) (*Pediculoides*)

A comparison of Hirst's (1921) drawing of *P. americanus* with the type of that species shows numerous differences in setation and the two are quite possibly distinct.

Habits. Little is known of the habits of the members of this subgenus. Vitzthum (1941), states that the mated but non-gravid females of *P. mesembrinae* ride upon adult flies and drop off at the oviposition sites where they attack the developing larvae. The same author states that the same species has been shown to attack the gall midge, *Cecidomyia saliciperda* Dut. in the same manner.

According to the above author, female mites identified as *P. mesembrinae* have been taken from the following flies in Europe: *Mesembrina mystacea* L., *Musca domestica* L., *Stomoxys calcitrans* (L.), *Siphona irritans* (L.), *Strathiomys* (*sic!*) sp., and various Borboridae. The same author described *P. heliocopridis* from an Asian *Heliocopris.* In the United States, Banks described *P. americanus* from *Musca domestica* L. Other host records may be obtained from the list below.

Specimens Examined. *Pediculaster americanus* Banks, Lectotype female (here designated) and four syntype females from Washington, D. C., Jan. 30, 1915 (U.S. N. M. No. 6984). In addition, eight unidentified species from many localities in the United States and from Mexico (Baja California) and from Haiti, from the following situations or hosts: *Musca domestica* L., anthomyiid fly (prob. *Fannia*), thorax of "Muscidae," thorax of Ephydridae, thorax of *Leptocera* (Diptera, Borboridae), from "fly," from *Diatraea* (Lepidoptera) in rearing cage, peach orchard soil, in manure, on commercial mushrooms, on leaves of *Azalea* sp., treehole of *Fagus*

grandifolia Ehrh., nest of *Peromyscus truei* (Shufeldt), nest of *Neotoma albigula* Hartley, ground litter in forest of roble and pines (Baja California).

Pygmephorus Kramer

(Figs. 59-60)

Pygmephorus Kramer, 1877, Archiv für Naturgeschichte, 43(1):248-259. Type, *Pygmephorus spinosus* Kramer, by original designation.

This genus was erected to contain a single species taken from a mole. Beginning with Canestrini (1880), but due chiefly to the various works of Berlese and Oudemans, the limits of the genus became increasingly broad. Krczal (1958, 1959b) includes all those forms comprising the present author's subfamily Pygmephorinae except that he has retained *Microdispodides* Vitzthum, 1914. In this paper the genus is restricted to those forms defined in the diagnosis below.

Members of the genus are most closely related to those of *Pediculaster* and *Microdispodides*. They differ from the former in the shape and size of leg I, the shape and size of seta *c* of trochanter I, the conformation of the ventral apodemes, the shape and position of the peritremes, and other characters. They differ from the latter in the character of leg I, in the type of integumental engraving, and in other characters.

Species of *Pygmephorus* are known to occur in Europe, South Africa, and North and South America. Several forms occurring on mammals have been found in Iceland, Greenland, and Point Barrow, Alaska. Only the females are known.

DIAGNOSIS. Females separable from those of all other genera in the family by the following combination of characters: three pairs of propodosomal dorsals [Kramer, in his original description and illustrations, indicated *spinosus* to have but two pairs of propodosomal dorsals. Although the author has not seen the type of *spinosus*, an inspection of many specimens believed to be that species (or relatives not separable from it by the original description) showed all to possess three pairs of propodosomal dorsals. The author therefore concludes that Kramer was either unable to observe the third pair or that *spinosus* was described from abnormal specimens. It should be further pointed out that because of its wide distribution and host range, it is quite possible that *spinosus*,

as now understood, will prove to be several closely related species]; leg I four-segmented; seta *c* of trochanter I short, semimembranous, bladelike, the apical portion proflexed; claw I large, sessile.

Description of Non-gravid Female. Length, 110 to 520μ; width, 75 to 220μ; width between anterior sternocoxal condyles of coxae III 55 to 170μ; hysterosoma oval to elliptical, its posterior margin broadly rounded or truncate; integument often with large, deep punctae, appearing "pebbled."

Gnathosoma. District, squarish or slightly longer than wide, normally directed anteroventrally or ventrally; palps free, distinct, with one or more apical teeth; chelicerae tiny, indistinct; large, ventral esophageal-pharyngeal pump absent, esophagus usually plainly visible as a simple tube.

Propodosoma. Dorsum. Inversely T-shaped, often greatly elongated behind pseudostigmata, anterior portion prolonged hoodlike over gnathosoma; margins of circumgnathosomal foramen heavily sclerotized, at least laterally, to form "collar" which encloses basal third to quarter of gnathosoma; posterior margin well covered by anterior margin of first hysterosomal tergum; peritremes widely separated, dorsal and circular, ovoid, or elongate troughlike and terminating anteriorly in propodosomal "shoulders"; esophageal "finned" structures distinct or not, if so then two in number, the anteriormost globose to subquadrate. *Venter.* Anterior ventral plate with four to six pairs of setae, if ventrites II with two pairs then internal ventrals about as close to anterior median apodeme as to external ventrals; ventral externals I forked or not; coxa I articulated at nearly a right angle to the longitudinal axis of body or distinctly obliquely; apodemes II strong, straight or weakly arcuate, complete medially; secondary transverse suture absent; anterior median apodeme very strong, complete; posterior marginal apodemes strong, complete; pleated conjunctival band indistinct between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment entire, its anterior margin overlapping posterior margin to posterior fourth of propodosoma; fifth segment well developed but usually completely enclosed by fourth in dorsal aspect, bearing three pairs of ventral or apicoventral setae; vulva apical or nearly so, vagina enclosed apically by a distinct, sclerotized, elliptical or globose enlargement, its shape dependent partly upon mount; posterior genital sclerite often globose,

never triangular and flaplike; anterior genital sclerite distinctly posterior to line drawn between posterior margins of coxal foramina IV; median genital sclerite absent. *Venter.* Posterior ventral plate entire, its hind margin also entire; posterior ventral plate bearing six pairs of setae; external presternal well posterior to and scarcely laterad of internal presternal, arising from or not more than two areolar widths in front of apodemes IV; external poststernal present, varying in position; apodemes III weak, often intermittent, not bending posteriorly to join anterior sternocoxal condyles III; apodemes IV distinct only medially, extending about half way to coxae III, directed toward center of coxal foramen; apodemes V present or absent; posterior median apodeme distinct, arising from vicinity of internal presternals and extending posteriorly at least as far as second axillaries; band of opisthosomal conjunctival pleats present or absent; opisthosoma distinctly longer than distance between anterior margin of coxa III and posterior margin of coxa IV.

Legs. All legs well developed, bearing claws; leg I shorter and thicker than leg II; tibiotarsus I elliptical, quadrate, or subpentagonal, often enormously enlarged, always distinctly wider than other segments of leg; pinnacula present or not, if present then arising from median portion of ventral surface of segment; large, rounded, mediolateral sclerotized plate present on tibiotarsus I; claw I enormously developed, furnished with an equally well developed bladelike thumb which may have a single tooth along its inner margin; trochanter I with three or (usually) four setae, seta *c* short, bladelike, semimembranous, the apical portion often proflexed; solenidia of tibiae II and III present or absent; tarsus II with five to seven setae and a solenidium, tarsus III with five to seven setae; claws II to IV simple or (usually) with rounded basal dilations; pulvilli II to IV well developed; coxa III subtriangular or subcordate; coxa IV short-rectangulate to elongate and slightly bulbose basally; tarsus IV slightly to distinctly longer than tarsus III, tapering abruptly; ratio of femurogenu IV to tarsus IV 1:3.0 to 1:5.0.

Species thought to belong in *Pygmephorus:*

ceratophyi Krczal, 1959
crassipes Krczal, 1959
dominguezi Athias-Henriot, 1961
erlangensis Krczal, 1959
forcipatus Willmann, 1952
ignotus Krczal, 1959
islandicus Sellinck, 1940

karafiati (Krczal, 1959) (*Microdispodides*)
microti Krczal, 1959
soricis Krczal, 1959
stammeri Krczal, 1959
ursulae Krczal, 1959

HABITS. Little is known concerning the habits of the mites of this group. *P. spinosus* and its relatives are found in the nests and food caches and on the bodies of a variety of widely distributed small rodents and insectivores. The remaining forms are found in association with Coleoptera (Scarabaeidae, Buprestidae) or with trees. The possibility exists that the latter may more properly be associated with wood-inhabiting insects, at least during the phoretic period. Since the *P. spinosus* complex differs markedly from the other species of the genus in both structure and habitat, later research may prove it to deserve separate status. Females of the *spinosus* group become physogastric in the same manner as those of *Siteroptes*, the hysterosoma becoming ovoid rather than globose, however. The swelling may be less pronounced, the largest female seen by this author measuring approximately 700μ long, 400μ wide, and 550μ high.

SPECIMENS EXAMINED. At least five species from many parts of the eastern United States and Alaska, and from Canada, Germany, and Surinam, from the following situations or hosts: "mole," *Sorex araneus* L., S. *cinereus* Kerr, *Blarina brevicauda* (Say), *B. b. carolinensis* (Bachman), *Cryptotis* sp., *Microtus ochrogaster* (Wagner), *Peromyscus gossypinus* (LeConte), bumblebee nest in old lemming burrow, humus under log, under bark of dead tree, from cativo logs (Surinam), and from dung beetle.

Microdispodides Vitzthum

(Figs. 61-63)

Microdispodides Vitzthum, 1914, Zoologischer Anzeiger 44(7):315-328. Type, *Microdispodides wichmanni* Vitzthum, 1914, by original designation (= *Pediculoides amaniensis* Oudemans, 1912).

Previously known only from the type species, a second species of the genus is described herein. The genus stands closest morphologically to *Pygmephorus,* which it resembles in possessing three pairs of propodosomal dorsals, in having the peritremes well separated, in that apodemes II are straight or nearly so, because the vagina is encompassed apically within a sclerotized structure which is oval or elliptical in shape, and other characters. Its members may be separated from those of *Pygmephorus* by the shape of leg I and by the lack of claws on legs I and IV.

Members of the genus are known only from Africa [Cameroon and Tanganyika (German East Africa)] and Central America (Guatemala). They are phoretic upon beetles. Only the non-gravid females are known. *Diagnosis.* The non-gravid females are distinguished from those of all other genera in the family by the following combination of characters: three pairs of propodosomal dorsals and six pairs of propodosomal ventrals; seta *c* membranous and flaplike, proflexed apically; integument, at least in part, with scalelike engravings; leg IV clawless, pretarsus IV nearly as long as tarsus IV.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 135 to 235μ; width, 70 to 135μ; width between anterior condyles of coxa III approximately 90μ; hysterosoma oval, its posterior margin broadly rounded or truncate; body well sclerotized, portions of dorsal integument appearing scaled.

Gnathosoma. Squarish, normally directed anteroventrally or ventrally; chelicerae tiny, indistinct; ventral esophageal-pharyngeal pump absent; esophagus plainly visible as a simple tube.

Propodosoma. Dorsum. Irregularly trapezoidal, often elongate posteriorly behind pseudostigmata; anterior portion extending hoodlike over gnathosoma; circumgnathosomal foramen anteroventrad, its lateral margins only moderately sclerotized; posterior margin of propodosoma overlapping or weakly overlapped by first hysterosomal segment; three pairs of propodosomal setae; peritremes ("Augen" of Oudemans, 1915) widely separated, circular or guttate, opening anterodorsally, arising near anterolateral angles of propodosoma; esophageal "finned" structures paired, subequal, subglobose-rhomboidal. *Venter.* Anterior ventral plate with six pairs of setae; external ventrals I not furcate; coxa I articulated distinctly obliquely to longitudinal axis of body; apodemes II usually strong, complete, straight or barely sinuate; secondary transverse suture absent; anterior median apodeme distinct, complete or broken briefly in front of apodemes II; posterior marginal apodemes strong and complete; pleated conjunctival band between propodosoma and hysterosoma not visible.

Hysterosoma. Dorsum. First segment either overlapping or being overlapped by propodosoma, bearing two pairs of setae; fifth segment well developed but usually enclosed by fourth in dorsal aspect, bearing three pairs of apicoventral setae; vulva apical or nearly so; vagina surrounded by apical, sclerotized, elliptical, pump-

like enlargement; three genital sclerotizations, the posterior semicircular in part, the anteriormost the largest, possessing a pair of lateral projections; anterior genital sclerite well posterior to line drawn between posterior margins of coxae IV. *Venter.* Posterior ventral plate entire, bearing six pairs of setae; hind margin of posterior ventral plate entire, broadly emarginate; external presternal well posterior to internal presternal and mesad or laterad of latter, arising well anterior to apodeme IV; external poststernals present, long, only slightly behind line drawn between posteromesal articulations of coxae IV; apodemes III indistinct or fragmentary; apodemes IV distinct only medially, extending one-quarter to one-third of distance to coxae III, or with additional fragments of apodemes present between medial portions and coxae III; apodemes IV directed toward centers of coxal foramina; apodemes V lacking; posterior median apodeme distinct, arising from vicinity of internal presternals and extending posteriorly to vicinity of second axillaries; band of opisthosomal conjunctival pleats not distinct if present; opisthosoma distinctly longer than distance between anterior margin of coxa III and posterior margin of coxa IV.

Legs. Leg I distinctly shorter and thinner than leg II; tibiotarsus I elongate-elliptical, as wide or narrower than other segments of leg; pinnacula lacking; large, rounded, mediolateral sclerotized area absent on tibiotarsus I; claw I lacking; trochanter I with four setae; seta *c* bladelike, semimembranous, its apical portion proflexed; solenidia of tibiae II and III present; tarsus II with six setae and solenidium, tarsus III with six setae; pretarsi II and III moderately elongate, about half length of respective tarsi, pretarsus IV more elongate, slightly longer than tarsus IV; claws II and III present and stout with rounded basal dilations, claws IV lacking; coxa III subcordate or short-triangular; coxa IV rectangulate, slightly constricted and bulbose basally; tarsus IV about as long as III (excluding pretarsi), subrectangulate; ratio of femurogenu IV to tarsus IV about 1:1.5. *Habits.* Nothing is known of the habits of these mites. *M. amaniensis* is known from the Cameroons and from German East Africa (Tanganyika) upon *Polygraphus congonus* Wichmann and *Platypus dispar* respectively, at least the former residing beneath the elytra. Both hosts are members of the Scolytoidea, the former belonging in the Scolytidae, the latter in the Platypodidae. *M. pholidotus* is known only from a Guatemalan species of *Metamasius* (Curculionidae-Calendrinae).

Key to the Females of *Microdispodides*

1(*a*). Small, 135 to 150μ; first axillary adjacent to anteromesal margin of coxal foramen III; Africa.....*M. amaniensis* (Oudemans)

1(*b*). Larger, 210 to 240μ; first axillary two to three times its own length mesad of anteromesal margin of coxal foramen III; Central America *M. pholidotus*, new species, p. 162

Microdispodides pholidotus, new species

DIAGNOSIS. In addition to the key characters listed above, *M. pholidotus* differs from *amaniensis* in that the external presternals are mesad of the internal presternals, the external poststernals do not nearly reach the hind margin of the body, and in various other characters.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 223μ (212-239); width, 135μ (133-135); distance between anterior sternocoxal condyles III, 85μ (83-88); propodosomal dorsum with uniformly distributed, coarse, elongate punctae; discs of first three hysterosomal terga with bands of scalelike integumental engravings, broadest on first tergum; anterior three-quarters of tergum IV with dense, elongate punctae, appearing pilose; tergum V and venter of body nearly uniformly punctate, punctae distinctly smaller and rounder than those of propodosomal dorsum.

Gnathosoma. Quadrate, length [21] (25μ); width [21] (23-24μ); gnathosomal dorsals in transverse row, subequal in size; solenidium II large, barely capitate; solenidium I clavate, about four μ long; distance between first and second palpal setae about six μ.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets 47μ (45-47); all propodosomal dorsals stout, nude, short, posterior pseudostigmatals distinctly longer than others, 31μ (29-31), arising directly behind and close to external pseudostigmatal socket; anterior pseudostigmatals arising at a slightly greater distance directly anterior to above socket, shorter than others; stigmatals distinctly mesad of others, approximately 30μ apart. *Venter.* Internal ventrals I short, lanceolate, median and external ventrals I nude, flagellate, the three setae on each side arising in a straight line; setae of ventrites II linearly arranged as described for ventrites I, nude, flagellate, the externals longer than the others, subequal in size to externals I; internal and mesal ventrals II slightly mesad of internal and mesal ventrals I, externals II slightly laterad of externals I.

21. This measurement not possible from holotype.

Hysterosoma. Dorsum. Dorsal setae of first four segments stout, weakly lanceolate, inconspicuously spiculate, setae of segment V short, bristlelike; dorsals I arising behind middle of segment, 19μ (18-19) long, 39μ (37-42) apart; laterals I arising well anterior to dorsals I, 26μ (26-29), distance anterolaterad to respective dorsals nearly equal to that between dorsals; dorsals II subequal to laterals I in length, 80μ (78-83) apart; dorsals III like dorsals II, 36μ (36-42) apart; laterals III 21μ (21-24) long, about six areolar widths anterolaterad of respective dorsals; all setae of segment IV subequal in size, 14μ (14-15), dorsals 25μ (25-29) apart, laterals about the length of a seta anterolaterad; setae of segment V subequal in length, about five μ, distance between internal caudal and respective external caudal II 15μ (15-18); external caudal I distinctly closer to external caudal II than to internal caudal. *Venter.* First axillaries short, lanceolate, all remaining setae of posterior ventral plate nude and flagellate, variable in length; internal and external presternals subequal in length, externals distinctly mesad of internals and on transverse line with first axillaries; first axillaries about three times their own length mesad of anteromesal margin of coxal foramina III; second axillaries about 30μ long, internal poststernals about half as long, arising barely mesad of external presternals and well behind second axillaries; external poststernals about 40μ long, arising two areolar diameters posterior or posteromesad of sternocoxal condyles IV; apodemes III and IV fragmented.

Legs (all measurements in μ). *Length.* Leg I, 50 (47-51); leg II, 72 (72-74); leg III, 77 (75-80); leg IV, 110 (108-113). *Width.* Leg I, 13 (13-14); leg II, 17 (17-21); leg III, 14 (14-15); leg IV, 11 (11-14). *Segment lengths.* Tr I, 17 (14-17); tita I, 26 (26); tr II, 22 (22-24); ta II, 24 (24-25); ti III, 15 (14-16); ta III, 25 (24-25); cx IV, 33 (33-36); tr IV, 20 (18-22); fege IV, 11 (11-12); ta IV, 33 (33-34). *Setation.* Leg I: cx 1T, tr 3T + 1 specialized, fege 2T, tita 11T + 10S; leg II: cx 1T, tr 3T, fege 2T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T (+ 1S?), ta 6T.

Tibiotarsus I with six rodlike and four short, stout solenidia, the most basal of the latter the smallest; trochanter I with one long seta which reaches basal third of tarsus; solenidia of tibiae II and III small, clavate, basal, that of tarsus II basal, short, subelliptical; tarsi II and III each with blunt, ventral, apical spur, each possessing two stout, spinose setae in addition; coxa IV distinctly arcuate;

sensory peg of tibia IV indistinct; tarsus IV with three greatly enlarged terminal setae, the apical about five times length of tarsus.

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Female holotype and three female paratypes (nos. 1 to 3) from Guatemala (taken in quarantine at Philadelphia, Pa., Feb. 3, 1936, A. B. Wells) from *Metamasius sp.* Philadelphia No. 29318, U. S. N. M. No. 36-2773.

TYPE REPOSITORIES. Holotype and two paratypes (nos. 2 and 3) in U. S. National Museum, Washington, D. C. One paratype (no. 1) in the Snow Entomological Museum, The University of Kansas, Lawrence, Kansas.

Microdispini, new tribe

This tribe includes five genera, four of which are new and described herein. Three (*Myrmecodispus, Glyphidomastax,* and *Perperipes*) have been found only in association with doryline ants.

DESCRIPTION OF NON-GRAVID FEMALE. *Gnathosoma.* Usually distinctly longer than wide or, if rarely wider than long, then palps free; palps normal or elongate and fitted for piercing.

Propodosoma. Dorsum. With one (usually) or two pairs of setae, if two pairs, then second pair visible only under high (1000X) magnification; peritremes widely separated, ovate, elongate-elliptical, or troughlike and cylindrical, never circular; three esophageal "finned" structures always present, the center one enlarged, the posterior reduced, never nearly equalling it and usually smaller than or as large as anterior. *Venter.* Anterior ventral plate always with four pairs of setae; external ventrals I not furcate.

Hysterosoma. Dorsum. First hysterosomal tergum often prolonged anteriorly to cover most or all of propodosoma, if so, then margins both free and radially striated or not; segment V with two (usually) or three pairs of setae; posterior portion of vaginal wall only rarely sclerotized, never enclosed in enlarged, elliptical to globose pumplike structure; posterior genital sclerite variable, only rarely (in some *Microdispus*) broadly triangular, flaplike. *Venter.* Apodemes V absent.

Legs. Legs I articulated obliquely to longitudinal axis of body, thinner and usually shorter than (rarely as long as) legs II; claw I often absent, if present, pedicellate; mediolateral "sclerotized plate" lacking on tibiotarsus I; trochanter I with three setae, seta *c* always setiform; trochanter IV usually shorter than, rarely as long as coxa IV.

Key to the Genera of the Tribe Microdispini (Females)

1(*a*). Leg IV without claws; tarsi II and III each with a pair of large, basal, subrectangulate setae; palps elongated and acuminate apically; associated with doryline ants.....2

1(*b*). Leg IV with claws; tarsi II and III without setae modified as above; palps rarely elongated and acuminate apically; associated with doryline ants or not.....3

2(*a*). Body elliptical in dorsoventral aspect; leg IV at least 20μ longer than leg III; posterior margin of first hysterosomal tergum with about 12 broad teeth.....*Glyphidomastax*, new genus, p. 184

2(*b*). Body circular to sublimuloid in dorsoventral aspect; leg IV not more than 15μ longer than leg III; posterior margin of first hysterosomal tergum lacking teeth.....*Perperipes*, new genus, p. 188

3(*a*). Gnathosoma distinctly wider than long; chelicerae enlarged and bladelike.....*Peponocara*, new genus, p. 179

3(*b*). Gnathosoma never distinctly wider than long; chelicerae usually indistinct, if distinct then not bladelike.....4

4(*a*). Apodemes IV reaching the margins of coxal foramina III; opisthosomal sternum often with scalelike engravings; associated with doryline ants *Myrmecodispus*, new genus, p. 173

4(*b*). Apodemes IV never reaching more than, usually much less than four-fifths of distance to margins of coxal foramina III; opisthosomal sternum lacking engravings; associated with doryline ants or not *Microdispus*, p. 165

Microdispus Paoli

As conceived herein, this genus consists of at least eleven species placed in two subgenera, *Microdispus* and *Premicrodispus*. Although "typical" forms of these two groups differ markedly in their appearance, intergrades occur which are difficult to assign satisfactorily.

Largely because of the enlargement of the first hysterosomal tergum, *Microdispus* was originally placed in the family Scutacaridae by Paoli. In this paper, the genus is considered to be closely related to species of *Pseudopygmephorus* and therefore contains the least specialized forms of the tribe Microdispini.

Members of the genus differ from scutacarids and resemble most pyemotids in that the first hysterosomal segment does not project beyond the gnathosoma and lacks radial strengthening striations along its margins, because legs II and III are well separated, in that the posterior ventral plate is not well delimited laterally in front of coxae III, because the peritremes are usually dorsal and oval or cylindrical, in the length of the legs, the ventral position of coxal seta IV, the shape of the posterior genital sclerite, and in the location of the presternals, in that the posterior margin of the posterior ventral plate is often trilobate, by the setiform structure of seta *c*, the position of apodemes IV, and other characters. The genus presents an observable sequence of modifications of the posterior

ventral plate accompanied by an interesting migration of setae. In most *Premicrodispus*, the first axillaries are situated nearly upon the coxal foramen. In *Microdispus*, these setae are progressively farther forward, and in some species may be the length of the coxa anterior to the latter. Apodemes IV, bearing the external presternals, undergo a similar but even more pronounced anterior migration and are often so close to apodemes III that the stem of the posterior median apodeme is very short or virtually absent.

Species are known from Europe, North and Central America, and Australia. Only the females are known.

DIAGNOSIS. Females of this genus are separable from those of *Pseudopygmephorus* by the characters of the tribe and from those of *Myrmecodispus* in lacking an engraved hysterosomal sternum and because apodemes IV do not reach coxal foramina III.

DESCRIPTION OF FEMALE. Small mites, length, 140 to 230μ; width, 50 to 130μ; distance between anterior sternocoxal condyles III, 40 to 75μ; hysterosoma elliptical to oval, its posterior margin broadly rounded or subtruncate; body weakly to moderately sclerotized, lacking integumental engravings, but most lateral portions of posterior ventral plate usually with 2 to 12 distinct pleats.

Gnathosoma. Well developed, slightly to distinctly longer than wide; palps with one or more apical teeth but not sharply acuminate; esophagus slender, appearing straight or variously spiralled or coiled.

Propodosoma. Dorsum. Inversely T-shaped or elongate and trapezoidal, slightly to well developed behind pseudostigmatal sockets; anterior portion of dorsum prolonged hoodlike over gnathosoma, foramen appearing ventral, only weakly sclerotized, not forming distinct collar; posterior margin to entire dorsum covered by first hysterosomal segment; one pair of propodosomal setae or (rarely), if two pairs, then second pair visible only under high (1000 ×) magnification; peritremes anterior, dorsal or dorsolateral, widely separated, diverging anteriorly, oval, elliptical, or elongate and troughlike, if the latter then terminating anteriorly in propodosomal "shoulders"; two or three subcontiguous esophageal "finned" structures present, the anterior present or not, if present, resembling a "bow-tie," the middle usually much the longest, rectangulate, the esophagus distinctly thickened within it, the third squarish, subglobose, or triangulate, often indistinct. *Venter.* Internal ventrals II arising anterior to external ventrals II, usually closer

to them than to anterior median apodeme; external ventrals I not furcate; coxa I articulated at nearly a right angle to longitudinal axis of body or (usually) distinctly obliquely; apodemes II complete or incomplete medially, together V- or weakly W-shaped; secondary transverse suture present or absent; anterior median apodeme usually strong and complete, rarely incomplete or absent; posterior marginal apodemes well developed, complete; distinct band of conjunctival pleats absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. Four or five visible segments; first segment overlapping posterior quarter to entire propodosoma, but margins not projecting free, not radially striate; fifth segment well developed, completely covered by fourth in dorsal aspect or not, bearing (usually) two or three pairs of apicoventral setae; vulva apical or apicoventral, often indistinct; apical portion of vaginal wall not sclerotized, not enclosed by sclerotized elliptical to globose enlargement; posterior genital sclerite straplike to broadly triangular; anterior genital sclerite distinct, acuminate, variable in position. *Venter.* Posterior ventral plate entire, bearing five or six pairs of setae, its hind margin entire or tripartite, if tripartite then incisions extending anteriorly to posteromesal margins of coxal foramina IV; first axillaries arising nearly in line with or distinctly anterior to anterior margin of coxal foramina III; external presternals arising directly behind internal presternals or well laterad of them but always on apodemes IV; external poststernals present, not or only slightly posterior to line drawn between posterolateral margin of coxal foramina IV; internal poststernals present or (rarely) absent; apodemes III absent or present, if present straight, complete mesally; apodemes IV distinct only mesally, extending one-half to four-fifths of distance to coxal foramina III, directed towards anterior half of foraminal margin or (rarely) directed well anterior to foramina; posterior median apodeme distinct, extending posteriorly to vicinity of coxae IV; distinct band of opisthosomal conjunctival pleats absent; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV.

Legs. Leg I thinner than, shorter or as long as leg II; tibiotarsus I elongate, elliptical to cylindrical, as wide as or narrower than femurogenu I; pinnacula present or lacking, if present then terminal and bearing a pair of rodlike solenidia; mediolateral "sclerotized plate" of tibiotarsus I absent; claw I absent; tarsi II and III each

with five or six tactile setae; solenidia of tibiae II and III (probably)[22] present; pretarsi short, one-quarter the length of the tarsi or less; claws II to III with or without basal dilations, distinctly larger than claws IV or not; length of pulvilli variable; coxa III triangular, subcordate or broadly crescent-shaped; coxa IV short-rectangulate to rectangulate, evenly dilate basally or with slight to pronounced basal bulblike dilation but lacking subbasal constriction; trochanter IV not longer, usually distinctly shorter than coxa IV; femurogenu IV with 1 seta; tarsus IV always distinctly longer than, often twice as long as tarsus III; ratio of femurogenu IV to tibiotarsus IV approximately 1:3.3 to 1:5.5.

Key to the Subgenera of *Microdispus* (Females)

1(*a*) With the following combination of characters: hind margin of posterior ventral plate entire; leg I distinctly shorter than leg II; apodemes IV meeting posterior median apodeme on or in front of line drawn between anterior sternocoxal condyles III..... *Microdispus* s. str., p. 172

1(*b*). Hind margin of posterior ventral plate usually tripartite; leg I shorter than or as long as leg II; apodemes IV meeting posterior median apodeme on or posterior to line drawn between anterior sternocoxal condyles III..... *Premicrodispus*, new subgenus, p. 168

Premicrodispus, new subgenus

(Figs. 64-66)

Type, *Microdispus* (*Premicrodispus*) *chandleri*, new species.

Forms of this subgenus present an interesting morphological transition between certain forms of *Pseudopygmephorus* on the one hand and forms of *Microdispus s. str.* and *Myrmecodispus* on the other. Most *Premicrodispus* resemble most *Pseudopygmephorus* in general body shape, in the shape and location of apodemes IV, in the position of the presternals, in having a tripartite posterior ventral plate, in the shape and position of the pseudostigmata, in possessing an elongate gnathosoma and elongate legs I, in the shape of the propodosoma, and in other characters. They differ from *Pseudopygmephorus* in the tribal characters given above.

As presently conceived, the subgenus contains at least six species, four of which are previously undescribed. These fall into two distinct species groups. The first of these is most closely related to *Pseudopygmephorus* and includes four species, all found in decaying vegetation. Members of this group are widely distributed, one species (undescribed) known only from Australia, one from Europe and North America (*silvestris* Jacot, 1936), one reported only from

22. Not visible on some poorly mounted specimens of *Microdispus s. str.*

Europe (*angustus Krczal,* 1959) and one restricted to North America (*chandleri,* n. sp.). The second group, associated with insects, resembles certain species of *Myrmecodispus* in the shape of the hind margin of the anterior ventral plate, in the shape and size of claws II and III, and in having seta *l* of tibia IV enormously enlarged. Included in this group are two species, one phoretic upon the termite *Reticulitermes flavipes* in Indiana, the other from the doryline *Nomamyrmex hartigi* in Panamá. The discrepancy in hosts may be explained by the fact that the specimens of *N. hartigi* were raiding a termite colony when captured.

Diagnosis. In addition to the key characters mentioned above, separable from most species of *Microdispus s. str.* as well as from *Myrmecodispus* by the shape of coxa IV, which is not or only barely bulbose and distinctly wider at base than at apex.

Description of Non-gravid Female. Length, 140 to 210μ; width, 50 to 90μ; width between anterior sternocoxal condyles III, 40 to 75μ.

Propodosoma. Dorsum. Well developed behind pseudostigmatal sockets. *Venter.* Secondary transverse suture absent.

Hysterosoma. Dorsum. First segment overlapping only posterior third to quarter of propodosoma; posterior genital sclerite straplike or tonguelike, anterior genital sclerite well posterior to line drawn between posteromesal margins of coxal foramina IV. *Venter.* Hind margin of posterior ventral plate usually tripartite; first axillaries arising nearly in line with anteriormost margins of coxal foramina III; apodemes IV meeting posterior median apodeme on or behind line drawn between anteriormost margins of coxal foramina III.

Legs. Pinnacula of tibiotarsus I lacking; coxa III triangular to short-subcordate; coxa IV more or less evenly dilated toward the base, not or only barely bulbose basally; tarsus IV not usually twice as long as tarsus III, ratio of femurogenu IV to tarsus IV approximately 1:3.8 to 1:4.6.

Previously described forms thought to belong in *Premicrodispus:*

angustus (Krczal, 1959) (*Pygmephorus*)
silvestris (Jacot, 1936) (*Pygmephorus*)

Habits. See above.

Specimens Examined. *P. silvestris* (Jacot) and four additional unidentified species from Kansas, Indiana, Panamá (C. Z.) and from Western Australia, from the following situations or hosts: *Eucalyptus* sp., punky stump, *Nomamyrmex hartigi* (Westwood) (Formicidae, Dorylinae), *Reticulitermes flavipes* (Kollar) (Isoptera).

Microdispus (*Premicrodispus*) *chandleri*,[23] new species

DIAGNOSIS. This species is most closely related to *silvestris*. It may be separated from that species, as well as from *angustus*, in that laterals III are spaced about two-thirds their own length from their respective dorsals, and by the three pairs of setae on segment V.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 156μ (148-162, $\bar{X} = 153.66$); Width[24] (79μ); width between anterior sternocoxal condyles III, 42μ (39-43, $\bar{X} = 41.60$); hysterosoma elliptical, weakly sclerotized, indistinctly punctate; posterior ventral plate laterad of legs with three to four longitudinal striae.

Gnathosoma. Rectangulate, length, 23μ (22-24, $\bar{X} = 22.66$); width, 12μ (12-13, $\bar{X} = 12.66$); internal dorsals submarginal, the externals small, marginal, usually not visible in dorsoventral aspect; solenidia I and II indistinct, probably absent; distance between first and second palpal setae about three μ; esophagus with series of two to four close spirals between buccal cavity and propodosomal "finned" structure.

Propodosoma. Dorsum. Thickly T-shaped; distance between internal pseudostigmatal sockets 25μ (22-25, $\bar{X} = 23.60$); single pair of pseudostigmatals appearing to arise on or near anteromesal margin of external pseudostigmatal sockets, these stout, as long as pseudostigmata, sparsely spiculate; peritremes elongate-elliptical, about two and one-half times longer than wide, anterior terminations lateral, not reaching anterior propodosomal margin. *Venter.* All ventral setae nude, flagellate, those of ventrites I subequal, about 12μ, externals II 17 to 20μ, internals II slightly shorter; apodemes II together U-shaped, complete; posterior marginal apodemes moderately arcuate.

Hysterosoma. Dorsum. Posterior margins of segments I to III emarginate, that of third much more broadly than others; all dorsal hysterosomal setae stout, sparsely spiculate; dorsals I arising about three-quarters of their own length posterior to laterals I, 14μ ($\bar{X} = 14.00$) long, 31μ (28-30, $\bar{X} = 29.80$) apart; laterals I 25μ (23-26, $\bar{X} = 23.83$) long; dorsals II subequal to dorsals I in size, 26μ (25-26, $\bar{X} = 25.50$) apart; dorsals III subequal to dorsals I and II in size, 18μ (15-18, $\bar{X} = 16.16$) long, 24μ (22-26, $\bar{X} = 24.00$) apart; laterals III 15μ (13-15, $\bar{X} = 13.83$) long, about two-thirds their own length

23. This species is named in honor of Dr. Leland Chandler, Department of Entomology, Purdue University, Lafayette, Indiana.

24. This measurement not possible from holotype.

posterolaterad of dorsals III; setae of tergum IV in transverse row, dorsals IV 20μ long (19-21, $\bar{X} = 19.50$), only 9μ (8-9, $\bar{X} = 8.16$) apart, laterals IV 18μ (17-19, $\bar{X} = 17.80$) long, about twice as far from respective dorsals as dorsals from each other; setae of segment V equidistant from each other, the internal caudals and external caudals II subequal in size, approximately 17 to 19μ, external caudals I bristlelike, about seven to eight μ; vulva seemingly apicoventral, its posterior extremity marked by a crescentic line; posterior genital sclerite short and tablike. *Venter.* Posterior ventral plate with five pairs of setae (internal poststernals lacking), all nude, flagellate, about 13 to 19μ; external presternals only slightly laterad of external poststernals, in longitudinal line with internal presternals, about six to eight μ behind line drawn between posteromesal margins of coxal foramina IV; first axillaries immediately adjacent mesally to anterior sternocoxal condyles of coxae III.

Legs (all measurements in μ). *Length.* Leg I, 37 (37-39, $\bar{X} = 38.00$); leg II, 46 (41-47, $\bar{X} = 45.33$); leg III, 43 (37-43, $\bar{X} = 41.46$); leg IV, 62, (58-64, $\bar{X} = 61.80$). *Width.* Leg I, 8 (8-9, $\bar{X} = 8.16$); leg II, 11 (10-12, $\bar{X} = 11.66$); leg III, 9 (8-9, $\bar{X} = 8.66$); leg IV, 10 (9-11, $\bar{X} = 9.83$). *Segment lengths.* Tr I, 14 (14-15, $\bar{X} = 14.17$); tita I, 18 ($\bar{X} = 18.00$); tr II, 17 (14-17, $\bar{X} = 15.50$); ta II, 15 (15-17, $\bar{X} = 16.00$); ti III, 7 ($\bar{X} = 7.00$); ta III, 15 (13-15, $\bar{X} = 14.33$); cx IV, 20 (18-20, $\bar{X} = 19.33$); tr IV, 17 (15-17, $\bar{X} = 15.40$); fege IV, 6 (6-7, $\bar{X} = 6.50$); ta IV, 20 (20-22, $\bar{X} = 21.00$). *Setation.* Leg I: cx 0T, tr 3T, fege 4T, tita 10T + 9S; leg II: cx 1T, tr 3T, fege 2T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tibiotarsus I with five rodlike and four, short, stout solenidia, the most anterior and lateral of the latter not reaching tip of segment; solenidia of tibiae subbasal; solenidium of tarsus II elongate, about eight μ; coxa III distinctly triangulate in ventral aspect; coxa IV quadrate, evenly and distinctly dilate toward the base; tarsus IV short, constricted abruptly three-fifths of distance to its apex; claws II to IV simple, subequal in size, pulvilli II to IV not longer than claws.

Distribution. Known from Michigan, Indiana, and Georgia.

Type Material. Female holotype and five female paratypes from near Hovey Lake State Game Refuge, Posey County, Indiana, June 6, 1958, E. A. Cross, from rotten stump in wet woods (berlese sample). Purdue University No. PU580605-5.

TYPE REPOSITORIES. Holotype and one paratype (no. 3) in the U. S. National Museum. Two paratypes (nos. 1, 4) in the Snow Entomological Museum, The University of Kansas. One paratype (no. 2) in the Blatchley Collections, Purdue University, and one paratype (no. 5) in the Zoologisches Institut, Universität Erlangen, Erlangen, Germany.

Subgenus *Microdispus* Paoli s. str.

(Figs. 67-68)

Microdispus Paoli, 1911, Redia (Firenze), 7:267. Type, *Diversipes* (*Microdispus*) *obovatus* Paoli, 1911, by original designation.

Typical members of this group show several specializations also found in the family Scutacaridae, a fact which led Paoli to place *M. obovatus* in the genus *Diversipes*. These specializations include an anterior migration of the external presternals in addition to the characters mentioned in the following diagnosis. The author follows Krczal in the belief that the genus belongs in the Pyemotidae for reasons already given.

The subgenus includes at least five species from Europe, North America, and Australia.

Diagnosis. In addition to the key characters, the first hysterosomal tergum is usually elongated anteriorly to cover all or nearly all of the propodosoma, and tarsus IV is usually characteristically attenuate and always elongate (figs. 67-68).

DESCRIPTION OF NON-GRAVID FEMALE. Length, 130 to 230μ; width, 80 to 130μ; width between anterior sternocoxal condyles III, 45 to 65μ; hysterosoma usually oval, rarely elliptical.

Gnathosoma. Always distinctly longer than wide.

Propodosoma. Dorsum. Inversely T-shaped; one pair of propodosomal setae; peritremes elongate-troughlike, terminating anteriorly in propodosomal "shoulder." Apodemes II together, if complete, U-shaped.

Hysterosoma. Dorsum. First tergum usually elongated anteriorly to cover entire propodosoma; fifth segment always with two pairs of setae; posterior genital sclerite usually narrowly wedge-shaped, rarely broadly wedge-shaped or straplike. *Venter.* Posterior margin of posterior ventral plate entire, bearing six pairs of setae; first axillaries arising distinctly anterior to coxae III, usually by more than half the length of the foramen; internal poststernals present; apodemes IV joining posterior median apodeme on or (rarely) above line drawn between anterior sternocoxal condyles III.

Legs. Leg I distinctly shorter than leg II; tibiotarsus I elongate, cylindrical, slightly to distinctly narrower than femurogenu I; tarsi II and III with six tactiles; claws II and III with basal dilations, distinctly larger than claws IV; coxa IV broadly to narrowly rectangulate, barely to (usually) greatly dilated bulblike basally; trochanter IV distinctly shorter than coxa IV; tarsus IV elongate, usually characteristically evenly attenuate; ratio of femurogenu IV to tarsus IV approximately 1:3.3 to 1:5.5.

Species thought to belong to *Microdispus, s. str.:*

obovatus (Paoli, 1911) (*Diversipes,* Scutacaridae)
setosus (Evans, 1952) (*Diversipes*)

Habits. Several species contain single, large eggs, suggesting that the size of the gravid female is similar to that of species of scutacarids and extreme physogastry is lacking. Habits are otherwise unknown.

Specimens Examined. Five species from the eastern part of the United States and from Australia (West Australia), from the following situations or hosts: leaf litter, pine litter, dead grass, molding hemlock and deciduous tree leaves, soil in peach orchard, punky stump in woods.

Myrmecodispus, new genus

(Figs. 69-71)

Type, *Myrmecodispus dorylinis,* new species.

This genus is erected to accommodate five undescribed species of microdispines, all of which are found in association with various Central American army ants. One species (no. 2) exhibits an interesting variability of gnathosomal dimensions, the gnathosomal length of some specimens being a fifth longer than that of others. Complete intergradation seemingly occurs between the two extremes.

Only the non-gravid females are known.

Diagnosis. Females may be distinguished from those of the most closely related genus, *Microdispus,* by the following combination of characters: apodemes IV reaching the anteriormost margins of coxae III or nearly so; distinct subapical pinnacula present on tibiotarsus I. In addition, tarsus IV is very elongate, usually at least twice the length of tarsus III.

Description of Non-gravid Female. Length, 140 to 235μ; width, 90 to 125μ; width between anterior sternocoxal condyles of coxae III, 58 to 95μ; hysterosoma elliptical to oval, its posterior margin

broadly to rather sharply rounded; body moderately to distinctly sclerotized, opisthosomal venter usually with scalelike integumental engravings; most lateral portions of posterior ventral plate with 2 to 12 distinct pleats.

Gnathosoma. Longer than wide, often elongate and acuminate; palps with or without distinct apical teeth, sharply acuminate or not; chelicerae minute and indistinct to moderately distinct; esophagus plainly visible as a straight, simple tube.

Propodosoma. Dorsum. Quadrate-trapezoidal, not usually well developed behind pseudostigmatal sockets; anterior portion of dorsum prolonged hoodlike over gnathosoma, foramen appearing ventral, its lateral margins only weakly sclerotized, not forming distinct collar; posterior margin well covered by first hysterosomal segment; pseudostigmatal sockets arising from posterior third of dorsum; one pair of proposodosomal setae; peritremes widely separated, diverging anteriorly, ovate to ovate-elongate; two or three propodosomal "finned" structures present, the anterior resembling a "bow-tie," the middle always much the largest, rectangulate, the esophagus distinctly thickened within it, the third small, similar in size to the first. *Venter.* Ventrals I in nearly straight line across plate; internal ventrals II arising distinctly anterior to external ventrals II, distinctly closer to them than to anterior median apodeme; external ventrals I not forked; coxa I articulated distinctly obliquely to longitudinal axis of body; apodemes II weakly to moderately developed, often incomplete, if complete then together W-shaped or strongly arcuate; secondary transverse suture lacking; anterior median apodeme weakly to moderately developed, complete or incomplete; posterior marginal apodemes strongly arcuate or nearly forming a straight line, prominent to exceedingly well developed, often the most distinct apodemes upon the ventral surface; pleated conjunctival band absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment overlapping posterior one-quarter to posterior two-thirds of propodosoma; fifth segment always with two pairs apicoventral setae; vulva indistinct; apical portion of vaginal wall not sclerotized, not surrounded by apical, elliptical to globular pumplike enlargement; posterior genital sclerite straplike or tonguelike, anterior genital sclerite distinct, acuminate, well posterior to line drawn between posteromesal margins of coxae

IV or not. *Venter.* Hind margin of posterior ventral plate tripartite, incisions extending as far as foramen of coxa IV; posterior ventral plate with six pairs of setae; first axillary arising well anterior to coxa III; external presternal well posterior to internal but arising distinctly lateral to it, always on apodeme IV; external poststernal present, arising from posteromesal margin of coxal foramen or nearly so; apodemes III complete medially, weakly to moderately developed, always distinctly weaker than apodemes IV; apodemes IV well developed, complete medially and joining anterior margin to anterior one-fourth of coxal foramina III, usually joining posterior median apodeme at or above line drawn between anterior sternocoxal condyles; posterior median apodeme distinct, joining apodemes III anteriorly and extending posteriorly at least as far as line drawn between second axillaries; distinct band of opisthosomal conjunctival pleats absent; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV.

Legs. Leg I distinctly shorter and thinner than leg II; tibiotarsus I elliptoid, not wider than femurogenu I; one subapical pinnaculum present, bearing two or three rodlike sensory setae; mediolateral sclerotized plate lacking on tibiotarsus I; claw I absent to moderately developed, if present then always distinctly pedicellate and without thumb; tarsi II and III each with six tactile setae, solenidia of tibiae II and III present; pretarsi short, one-quarter length of tarsi or less; claws II and III stout and with distinct basal dilation, distinctly stouter than those of IV; pulvilli II to IV extending distinctly beyond claws; coxa III shortly subcordate to thickly crescent-shaped in ventral aspect; coxa IV short-rectangulate to rectangulate, not or barely bulbose basally; tarsus IV always very elongate and thin, nearly straight or tapering evenly, slightly less than to distinctly more than twice as long as tarsus III; ratio of femurogenu IV to tarsus IV, 1:4.3 to 1:9.0.

Habits. Little is known of the habits of these mites. To judge from the samples at hand, three species are apparently restricted in their host relationships to the single species *Nomamyrmex esenbecki.* The remaining two are found with more than one species of ant, *dorylinis* usually with *Eciton vagans* but rarely upon *E. hamatum*, and *Myrmecodispus species No. 1* from *E. vagans* and *E. dulcius.*

SPECIMENS EXAMINED. In addition to the type species as follows: *Species No. 1.* PANAMA (Canal Zone): Barro Colorado Island, 39 ♀ ♀ from *Eciton dulcius* Forel (Rettenmeyer Colony No. E-204); same, 1 ♀ from *E. vagans* (Olivier) (Colony No. E-154); same, 1 ♀ from *E. vagans* (Colony No. E-240); same, 4 ♀ ♀ from *E. vagans* (Colony No. E-180); same, 12 ♀ ♀ from *E. vagans* (Colony No. E-212). *Species No. 2.* PANAMA (Canal Zone): Barro Colorado Is., 20 ♀ ♀ from *Nomamyrmex esenbecki* (F. Smith) (Rettenmeyer Colony No. E-164). *Species No. 3.* PANAMA: Cerro Galera, 1 ♀ from *Nomamyrmex hartigi* (Westwood) (Rettenmeyer Colony No. D-118). *Species No. 4.* PANAMA (Canal Zone): Barro Colorado Is., 2 ♀ ♀ from *N. esenbecki* (Rettenmeyer Colony No. E-164).

Myrmecodispus dorylinis, new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 212μ (201-252, $\bar{X} = 215.10 \pm$ S. E. 2.43); width, 125μ (117-125, $\bar{X} = 120.33 \pm$ S. E. 0.70); distance between anterior sternocoxal condyles III, 90μ (80-90, $\bar{X} = 86.42 \pm$ S. E. 0.45); body ovate, moderately sclerotized, lacking integumental engravings.

Gnathosoma. Trapezoidal (appearing quadrate with palps extended); length, 30μ (24-30, $\bar{X} = 27.28 \pm$ S. E. 0.38); width, 24μ (22-24, $\bar{X} = 23.32 \pm$ S. E. 0.14); palps palmate, one dorsal tooth distinctly larger than rest; chelicerae of moderate size.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets, 52μ (47-55, $\bar{X} = 49.67 \pm$ S. E. 0.62); propodosomal seta about as long as pseudostigmatal pedicel. *Venter.* All setae moderate in size, nude, flagellate, 18 to 35μ long; internal ventral I only slightly larger than external ventral I, the former about 28μ long; internal ventral II less than width of one areolus of external ventral II anterior to external ventral II; apodemes II weak but complete, together W-shaped; posterior marginal apodemes heavy, straight, their most lateral corners bending dorsally, then anteriorly, to form large scapuloid plates.

Hysterosoma. Dorsum. First dorsal segment covering posterior one-third (posterior margin to posterior third) of propodosoma; setae of first segment in nearly transverse row, dorsals about a third longer than laterals and 77μ (69-77, $\bar{X} = 74.64 \pm$ S. E. 0.37) apart; dorsals II tiny, 9μ (8-12, $\bar{X} = 9.37 \pm$ S. E. 0.32) long, 67μ (58-68, $\bar{X} = 63.26 \pm$ S. E. 0.49) apart; dorsals III 57μ (51-58, $\bar{X} = 54.60$

± S. E. 0.37) apart, 69μ (59-75, $\bar{X} = 66.00 \pm$ S. E. 0.71) long; laterals III short, 18μ (13-19, $\bar{X} = 15.32 \pm$ S. E. 0.41) long, arising about half width of dorsal areolus laterad of dorsals; dorsals IV very elongate, 97μ (88-99, $\bar{X} = 93.72 \pm$ S. E. 0.71) long, 32μ (28-32, $\bar{X} = 30.63 \pm$ S. E. 0.18) apart; laterals IV subequal in size to laterals III but laterad of dorsals IV by the width of the dorsal areolus or more; internal caudals about 18μ, external caudals II about half the size of the internals and placed about length of dorsals II laterad of latter. *Venter.* All setae of posterior ventral plate flagellate, 14 to 29μ long, first and second axillaries and external poststernals subequal in size, distinctly larger than other three pairs; apodemes III moderately developed, complete medially and extending laterally beyond anteriormost margin of coxae foramina III, there recurving slightly; apodemes IV stout, becoming more so at sides, extending laterally to meet coxal foramina III along anterior margins, meeting posterior median apodeme behind line drawn between anterior margins of coxal foramina; external presternals arising distinctly laterad of internal presternals and larger than them; internal poststernals spaced subequally between second axillaries; external poststernals extending less than half way to posteriormost margin of opisthosoma; opisthosomal venter without scalelike engravings, its posterior margin entire.

Legs (all measurements in μ). *Length.* Leg I, 44 (39-44, $\bar{X} = 42.24 \pm$ S. E. 0.28); leg II, 66 (59-66, $\bar{X} = 62.24 \pm$ S. E. 0.30); leg III, 74 (68-74, $\bar{X} = 71.27 \pm$ S. E. 0.44); leg IV, 123 (117-124, $\bar{X} = 121.24 \pm$ S. E. 0.38). *Width.* Leg I, 14 (10-15, $\bar{X} = 13.68 \pm$ S. E. 0.24); leg II, 23 (19-24, $\bar{X} = 22.16 \pm$ S. E. 0.23); leg III, 20 (19-22, $\bar{X} = 20.24 \pm$ S. E. 0.18); leg IV, 19 (14-20, $\bar{X} = 17.92 \pm$ S. E. 0.32). *Segment lengths.* Tr I, 13 (13-14, $\bar{X} = 13.48 \pm$ S. E. 0.10); tita I, 22 (20-22, $\bar{X} = 21.04 \pm$ S. E. 0.14); ta II, 19 (15-19, $\bar{X} = 18.24 \pm$ S. E. 0.23); ti III, 14 (13-14, $\bar{X} = 13.28 \pm$ S. E. 0.09); ta III, 21 (17-21, $\bar{X} = 18.88 \pm$ S. E. 0.19); cx IV, 36 (35-37, $\bar{X} = 36.16 \pm$ S. E. 0.16); tr IV, 24 (22-24, $\bar{X} = 22.64 \pm$ S. E. 0.15); fege IV, 10 (9-10, $\bar{X} = 9.64 \pm$ S. E. 0.14); ta IV, 48 (47-50, $\bar{X} = 47.68 \pm$ S. E. 0.18). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 11S + 10T; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Legs II and III stout, barely tapering from trochanter to tibia; tarsi II and III short and constricted abruptly; tibiotarsus I ellip-

toid-tapering, with moderately sized claw borne upon distinct pedicel; pinnaculum short and broad, bearing two setae; dorsolateral margin of tibiotarsus I with three prominent bullet-shaped solenidia subequal in size and distance from one another, another solenidium present distally and basally to these; solenidium of tarsus II short and broadly clavate; coxa IV not basally bulbose; solenidium of tibia IV broader than that of III; tarsus IV moderately elongate, ratio of length of femurogenu IV to tarsus IV about 1:4.9.

VARIATION. Only a comparatively slight amount of variation was noted in this species, perhaps because many of the specimens examined were from the same ant colony. Asymmetrical variation between members of the same pair of caudal setae was found and, in such cases, the average length of the two setae was given as the length. This average is usually surprisingly similar to the individual measurements made from more "normal" specimens. It is thought that much of the variation in the width of the legs was due to the amount of pressure upon them and it was definitely noticed that the thinnest legs were associated with the highest mounts. Although only a few specimens of the former were available, there were no noticable differences between specimens found upon the two hosts *E. burchelli* and *E. vagans*.

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Female holotype and five female paratypes (nos. 5, 6, 7, 9, and 10) from Barro Colorado Island, Canal Zone, Panamá, August 7, 1956, M. E. and C. W. Rettenmeyer, from *Eciton vagans* (Olivier). Ten female paratypes (nos. 1, 2, 3, 4, 11, 12, 13, 14, 20, 24) as preceding but collected July 9, 1956. Three female paratypes (nos. 15, 16, 17) as above but collected May 31, 1956. Three female paratypes (nos. 8, 18, 19) as above but collected April 30, 1956. Three female paratypes (nos. 21, 22, 23) as above but collected August 17, 1956, from *Eciton burchelli* (Westwood).

TYPE REPOSITORIES. Holotoype and eight paratypes (nos. 1, 2, 5, 6, 20, 21, 22, 23) in the Snow Entomological Museum, The University of Kansas, five paratypes (nos. 3, 7, 16, 18, 19) in the U. S. National Museum, Washington, D. C., two paratypes (nos. 9 and 15) in the Zoologisches Institut, Universität Erlangen, Erlangen, Germany, two paratypes (nos. 4 and 8) in the British Museum (Natural History), two paratypes (nos. 10 and 11) in the Chicago Natural History Museum, two paratypes (nos. 12 and 13) in the

American Museum of Natural History, New York City, and two paratypes (nos. 14 and 17) in the private collection of Carl W. Rettenmeyer, Kansas State University.

Material Examined. Other than the type series, as follows: Panama (C. Z.): Barro Colorado Is., 163 ♀ ♀ from *Eciton vagans* as follows: Rettenmeyer Colony no. E-180, 11 ♀ ♀; no. E-219, 4 ♀ ♀; no. E-154, 32 ♀ ♀; no. E-212, 49 ♀ ♀; no. E-240, 67 ♀ ♀. Same, from *E. burchelli*, Colony no. E-253, 8 ♀ ♀.

Peponocara, new genus

(Figs. 78-80)

Type, *Peponocara cathistes*, new species.

This genus is erected to include a single new species of relatively unspecialized microdispine mite taken from a polyphagine roach, upon which it is probably parasitic. Superficially resembling a long-legged form near *Premicrodispus*, the species differs greatly from all other microdispines in the structure and shape of the gnathosoma. Gravid and non-gravid females are similar in appearance since, in the manner of *Microdispus*, the female seemingly matures only one egg at a time.

Diagnosis. Females are distinguishable from those of all other microdispine pyemotids by the shape and structure of the spherical, flattened gnathosoma. This structure has expanded anteriorly and laterally, with a consequent diminution and ventral displacement of the mouthparts. The chelicerae are large and distinctly bladelike, often extruded. Males and immatures are unknown.

Description of Non-gravid Female. Length, 175 to 250μ; width, 110 to 150μ (these variations due in part to enlargement of hysterosoma in gravid females); width between anterior sternocoxal condyles of coxae III, 70 to 75μ; hysterosoma ovate, its posterior margin well rounded; posterior margin of first hysterosomal segment lacking broad teeth; body moderately sclerotized; posterior portions of dorsal segments and of posterior ventral plate and often of opisthosomal venter with irregular, impressed lines, these usually increasingly distinct posteriorly; striae present on most lateral portions of posterior ventral plate but often difficult to see; punctae usually indistinct.

Gnathosoma. Well developed, free, greatly expanded laterally and slightly expanded anteriorly to displace and enclose mouthparts ventrally; palps distinct but greatly reduced, their apices

with at least one broad tooth; chelicerae enlarged, the stylets distinctly bladelike, often extruded, the guttate cheliceral bases prominent dorsally within the gnathosoma, separated by a heavily sclerotized septum that is bifurcate and recurved posteriorly; ventral esophageal-pharyngeal pump absent but posterior portion of bucca enlarged pumplike; esophagus plainly visible as moderately thick, straight tube possessing Z-like dorsal bend at posterior portion of gnathosoma or anterior part of propodosoma.

Propodosoma. Dorsum. Outline trapezoidal, about half as long as wide; lateral margins of gnathosomal foramen weakly developed, not forming a distinct collar; posterior margin well defined by apodeme, barely covered by first hysterosomal segment; one pair propodosomal setae arising directly in front of pseudostigmata; peritremes in anterior third, large, guttate and diverging about 150 degrees, opening near dorsolateral angles; three subcontiguous esophageal "finned" structures present, the anteriormost resembling a "bow-tie," the middle much the largest, rectangulate, the esophagus distinctly thickened within it, the posteriormost tiny, undulate. *Venter.* Ventral setae I nearly in transverse line; internal ventrals II well anterior to external ventrals II and much closer to them than to anterior median apodeme; external sternals I not forked; coxa I arising from ventral plate distinctly obliquely to longitudinal axis of body; apodemes II well developed and complete; secondary transverse suture lacking; anterior median apodeme intermittent behind apodemes II; posterior portion of anterior ventral plate not elongate, distance between apodemes I and II subequal to that between apodemes II and posterior marginal apodeme; posterior marginal apodemes straight, well developed, increasingly so laterally; pleated conjunctival band between propodosoma and hysterosoma absent.

Hysterosoma. Dorsum. Anterior margin of first segment barely covering posterior margin of propodosoma; fifth segment well developed but usually completely enclosed by fourth in dorsal aspect, bearing two pairs ventral setae; apical portion of vaginal wall not sclerotized, not surrounded by apical, sclerotized, elliptical to globose pumplike enlargement; vulva apical, moderately distinct; posterior vaginal sclerite distinct, irregularly spherical; posterior ventral plate with six pairs setae, its posterior margin entire; first axillaries about one-third length of coxa III anterior to coxae III; external presternals nearly directly behind internals, arising from apodemes IV; external poststernals present, arising barely mesad

of and posterior to posteromesal margins of coxal foramina IV; apodemes III indistinctly present, oblique, complete medially; apodemes IV moderately developed, complete medially but short, reaching less than half the distance to the foramina of coxae III, directed toward anterior sternocoxal condyles, meeting posterior median apodeme on level with line drawn between anteriormost foraminal margins; posterior median apodeme short, often faint, arising anteriorly at Y-shaped juncture with apodemes III, terminating posteriorly near line drawn between second axillaries; posterior ventral plate laterad of legs with series of six to ten nearly parallel striations, these often indistinct depending upon mount; band of opisthosomal conjunctival pleats lacking; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV; opisthosomal venter lacking scalelike engravings except occasional irregular lines near hind margin.

Legs. Moderately elongate to (leg IV) elongate, slender; leg I much longer than gnathosoma but distinctly shorter and thinner than leg II; tibiotarsus I elongate-elliptical, not wider than femurogenu I, lacking distinct pinnacula and mediolateral sclerotized area; claw I absent; tarsi II and III each with six normal tactiles; pretarsi short, a quarter the length of the tarsi or less, dilated toward the apex; claws II and III stout but short, without inner basal dilation; claws IV present but reduced, less than half size of preceding two pairs; pulvilli extending distinctly beyond claws; coxa III elongate, subcordate in ventral aspect; coxa IV rectangulate, slightly constricted at basal third; trochanter IV only slightly shorter than coxa IV; femurogenu IV elongate, about twice as long as wide, bearing one seta; tarsus IV thin and elongate, ratio of femurogenu IV to tarsus IV about 1:3.5.

Habits. Little is known of the habits of the single extant species. All specimens seen by the author were part of a single series taken from the polyphagine roach *Arenivaga apacha* (Saussure). The host roach belongs to a small, rather unique group of deserticolous species known in the United States only from the arid southwest. Because of the enlarged and bladelike chelicerae and because the gnathosoma has been torn from many of the specimens seen by the author, it is inferred that the species is a parasite which attaches rather firmly to the host. This belief is further strengthened in that many of the females are gravid.

In gravid females, extreme physogastry does not occur and the various segments remain telescoped within one another although an increase in hysterosomal size is obvious. All those examined possessed only a single, very large egg, this oval, 125 to 143μ long, 98 to 115μ wide. The extrusion of this egg through the apical vulva is seemingly impossible, and oviposition must occur either through some secondary opening or through hysterosomal breakdown. The author believes the former to be the case, positions and aspect of the vaginal sclerotizations and of the tissues between them being quite similar to those of *Perperipes* except for the muscular common oviduct, which was not observed in *Peponocara*. The distance between anterior and posterior vaginal sclerotizations is about 80 to 90μ in length, large enough to permit passage of the egg.

Males and immatures are unknown.

Peponocara cathistes, new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 178μ (178-241); width, 117μ (117-140); distance between anterior sternocoxal condyles III, 74μ (69-75).

Gnathosoma. Length, 24μ (23-25); width, 39μ (35-39); dorsal setae arising well laterad and in anterior fifth, usually appearing marginal; posteriors well posterolaterad of anteriors.

Propodosoma. *Dorsum*. Distance between internal pseudostigmatal sockets, 46μ (41-47); propodosomal seta long, 45 to 50μ, nude. *Venter*. Setae rather stout, length about 17 to 40μ, setiform or flagellate, nude; ventrals I of similar shape and size, arising nearly in a straight line; internal ventrals II much smaller than external ventrals and arising distinctly mesad of them; a straight line drawn between externals I and II well laterad of internal ventrals II; apodemes II broadly and flatly U-shaped.

Hysterosoma. *Dorsum*. All dorsal setae nude, elongate-flagellate; setae of first segment in straight line; dorsals I distinctly farther from each other than from respective laterals, and longer than them, length, 61μ (53-63); dorsals II slightly shorter than dorsals I and arising only 20μ (19-23) apart; dorsals III 42μ (41-45) apart, —[25] (39-50) long, laterals III much shorter, —[25] (17-24), arising well laterad of and equally posterior to dorsals; all setae of segment IV subequal in size, about 25 to 30μ, laterals slightly anterior to dorsals and much farther from them than dorsals from each other;

25. This measurement not obtainable from holotype.

setae of segment V apicoventral, internal caudals 15μ (14-18) long, as far from each other as from external caudals II, latter 21μ (18-23) long; external caudals I 8μ (8-12), distinctly closer to internal caudals than to external caudals II. *Venter.* All setae of posterior ventral plate nude, lanceolate-flagellate, about 17μ (internal presternals) to about 41μ (external poststernals) long; first axillaries well mesad of anterior sternocoxal condyles of coxae III; second axillaries arising between mid point and posterior third of coxal foramina III; external presternals twice as wide and about one and one-half times as long as internal presternals; internal poststernals arising slightly anterior to line drawn between posterior sternocoxal condyles IV; external poststernals reaching slightly more than half way to posteriormost margin of opisthosoma; posterior margin of opisthosomal venter irregularly sinuate, especially mesally.

Legs (all measurements in μ). *Length.* Leg I, 41 (36-41); leg II, —[26] (55-58); leg III, 64 (58-66); leg IV, 108 (108-112). *Width.* Leg I, 7 (7-8); leg II, 12 (9-12); leg III, 7 (7-9); leg IV, 7 (7-8). *Segment lengths.* Tr I, 14 (14-15); tita I, 20 (19-20); ta II —[26], (20-23); ti III, 11 (11-12); ta III, 23 (20-23); cx IV, 26 (25-26); tr IV, 22 (19-23); fege IV, 13 (12-13); ta IV, 41 (40-41). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 11T + 9S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tibiotarsus I with four lateral clavate or bullet-shaped solenidia of which the most basal is distinctly the longest, remaining five sensory setae rodlike; solenidia of tibiae II and III arising from near middle of segment; solenidium of tarsus II large, reaching areolus of tactile seta above it; coxa IV slightly constricted at basal third, enlarged dorsally distad of constriction, much wider than other segments of leg; external setae of trochanter and tibia IV distinctly longer than other setae of leg, that of trochanter reaching to tip of tarsus.

Variation. No unusual degree of variation was observed in the small series examined.

Distribution. Known only from the type locality.

Type Material. Female holotype and four female paratypes (two gravid) from Presidio, Presidio Co., Texas, September 5, 1949, J. H. Russell, from the blattid *Arenivaga apacha* (Saussure), U. S. N. M. Lot no. 49-19208.

26. This measurement not possible on holotype specimen.

TYPE REPOSITORIES. Holotype and three paratypes (nos. 1, 3, 4) in the U. S. National Museum, Washington, D. C. Remaining paratype in the Snow Entomological Museum, The University of Kansas.

SPECIMENS EXAMINED. Same data as type series, 5 females.

HABITS. See generic description.

Glyphidomastax, new genus

(Figs. 72-74)

Type, *Glyphidomastax rettenmeyeri*, new species.

This genus is erected to accommodate a single, rare, previously undescribed species found phoretic upon the two species of North American army ants *Neivamyrmex opacithorax* (Emery) and *N. nigrescens* (Cresson). Because of its heavy sclerotization, the shape of tarsus IV, and the character and size of the first hysterosomal tergum, the species superficially appears to belong to the family Scutacaridae. There seems little doubt, however, that it is most closely related to species of *Myrmecodispus*, also associated with doryline ants. It is, however, much more specialized than members of that genus, particularly as regards the gnathosoma, the shape of the body, and modifications of the tarsi and tarsal setae.

The mite is immediately separable from any scutacarid species in that seta *c* of trochanter I is setiform, by the shape of the propodosoma, in possessing only one pair of propodosomal setae, in that external caudals I are vestigial, because of the shape of apodemes IV and of the anterior ventral plate, in that the posterior genital sclerite is not broadly wedge-shaped, in the shape of the gnathosoma and palps, in that the posterior ventral plate is not defined laterally in front of coxae III, and other characters.

Only the non-gravid female is known.

DIAGNOSIS. Females are distinguished from those of all other genera except *Perperipes* in possessing a pair of enormous, rectangulate setae basally on tarsi II and III, by the shape of the gnathosoma, which is long and acuminate, and more especially by the shape of the palps, which are elongate and sharp, as if fitted for piercing. The body is elliptical and heavily sclerotized, unlike that of *Perperipes*.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 290 to 315μ; width, 160 to 185μ; width between anterior sternocoxal condyles III, 100 to 108μ; hysterosoma elliptical, posterior margin evenly rounded; posterior margin of first hysterosomal segment with comb of about

12 broad, short teeth; body well sclerotized, without "pebblings" or scalelike engravings but finely and evenly punctate; most lateral portions of posterior ventral plate without pleats but finely striate.

Gnathosoma. Well developed, acuminate, much longer than wide; palps unique, elongate, comprising about two-thirds length of gnathosoma, each terminating in two elongate bladelike teeth; chelicerae indistinct, perhaps degenerate; ventral esophageal-pharyngeal pump absent; bucca well defined; esophagus plainly visible as a simple, thick, straight tube, not spiralled or coiled within a membranous pouch.

Propodosoma. Dorsum. Anterior portion rounded, sides diverging posteriorly, posterior portion of plate indistinct; anterior portion prolonged hoodlike over gnathosoma, circumgnathosomal foramen ventral, its lateral margins only weakly sclerotized, not forming distinct collar; first hysterosomal segment covering entire dorsum; one pair of propodosomal setae; peritremes large, in anterior half, widely separated, elongate-oval, opening laterally; three subcontiguous esophageal "finned" structures present, the middle one greatly enlarged, its fins uneven and crooked, the anterior and posterior ones reduced. *Venter.* Ventrals I not in a straight transverse line; internal ventrals II arising well anterior to external ventrals and much closer to them than to anterior median apodeme; external ventrals I not forked; coxa I articulated to anterior ventral plate at angle oblique to longitudinal axis of body; apodemes II weakly to moderately developed, each present laterally and medially but absent between; secondary transverse suture lacking; anterior median apodeme moderately developed, broken two or three times posterior to junction of apodemes II; posterior marginal apodemes greatly enlarged, ten times width of anterior median apodeme, together forming an arc; pleated conjunctival band absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment semicircular and expanded anteriorly, completely covering propodosoma, margins projecting free and with radial striae, covering base of gnathosoma and basal two or three segments of legs I and II; fifth segment bearing three pairs of ventral setae, the middle pair degenerate; vulva apicoventral, indistinct; apical portion of vagina not surrounded by sclerotized, pumplike enlargement; posterior genital sclerite well internal, irregularly shaped; anterior genital sclerite acuminate, its anterior margin on line drawn between posteromesal margins of coxae IV.

Venter. Posterior ventral plate bearing six pairs of setae, greatly elongated anteriorly; hind margin of posterior ventral plate entire; external presternals well posterior to and slightly mesad of internal presternals, arising slightly in front of apodemes IV; external poststernals present; apodemes III absent or weak and hidden beneath greatly enlarged posterior marginal apodemes of anterior ventral plate; apodemes IV greatly enlarged, straight and perpendicular to longitudinal axis of body, complete medially and joining coxal foramina III at their anteriormost margins; posterior median apodeme arising between internal presternals and terminating posteriorly in region of internal poststernals; posterior ventral plate laterad of legs with numerous striae, apical striations less pronounced than basal; distinct band of opisthosomal conjunctival pleats absent; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV; opisthosomal venter lacking scalelike integumental engravings.

Legs. All legs comparatively short and stout, leg I extremely short, approximately the length of gnathosoma, distinctly narrower than leg II; tibiotarsus I subtriangulate, not wider than femurogenu I; distinct pinnacula and mediolateral sclerotized plate lacking on tibiotarsus I; claw I absent; tarsi II and III each with three normal tactiles and two enormous tactiles, the latter heavily sclerotized, rectangulate, bearing apical prickle; solenidia of tibiae II and III present; pretarsi short, one-quarter length of tarsi or less; claws II and III stout, with distinct basal dilations, claws IV lacking; pulvilli II and III extending distinctly beyond claws; coxa III subcordate in ventral aspect; coxa IV subrectangulate, slightly narrowed basally; trochanter IV less than half as long as coxa IV; femurogenu IV bandlike, bearing one seta; tarsus IV elongate and thin, evenly attenuate or nearly so, much less than twice as long as tarsus III; ratio of femurogenu IV to tarsus IV, 1:10.0.

Glyphidomastax rettenmeyeri, new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 296μ (315); width, 159μ (186); distance between anterior sternocoxal condyles III, 101μ (111).

Gnathosoma. Length, 50μ (51); width, 19μ (20); distance between palpal setae, 11μ (12); posterior dorsal setae well behind and laterad of anterior dorsals (or appearing directly behind).

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets, 48μ (52); propodosomal seta short and nude, 9μ (8), situated on prominence about its own length anterior to pseudostigmatal organ; apodeme delimiting posterior margin of plate lacking. *Venter.* Setae moderate to stout in size, length, 28 to 55μ, flagellate, nude to sparsely plumose; internals I about 55μ, half again as large as externals I; internals and externals II subequal in size, about 43μ, both pairs approximate to coxal foramen II, internals nearly as far from externals II as from externals I; anterior ventral plate elongated behind apodemes II, distance between apodemes I and II much less than that between apodemes II and posterior marginal apodemes.

Hysterosoma. Dorsum. Setae of first segment slender, flagellate, dorsals weakly plumose, slightly shorter than and posterior to nude laterals; setae of segments II to V stout and weakly plumose; dorsals II 88μ (85) apart, 55μ (63) long, located above centers of coxae III; dorsals III 70μ (76) apart, 74μ (78) long, laterals III well anterior and lateral of dorsals, nearly marginal, 66μ (66) in length; setae of segment IV spaced subequally, dorsals 68μ (72) long, laterals longer, 88μ (96); setae of segment V distinctly ventral, internal caudals 52μ (52), external caudals I rudimentary, their areoli contiguous with those of internals; external caudals II about two areolar widths laterad of internal caudals, 33μ (31) in length. *Venter.* All setae of posterior ventral plate nude, flagellate, 22 to 50μ; first axillaries anterior to coxal foramina III by about length of coxa III; apodemes IV forming a straight line; second axillaries arising from posterior third of margin of coxal foramina III; external presternals about two-thirds length of internal presternals; internal poststernals close together, straddling posterior median apodeme, arising anterior to second axillaries; external poststernals extending less than half way to posteriormost margin of opisthosoma; opisthosomal venter without scalelike engravings, its posterior margin entire.

Legs (all measurements in μ). *Length.* Leg I, 48 (48); leg II, 86 (90); leg III, 88 (90); leg IV, 120 (123). *Width.* Leg I, 19 (20); leg II, 30 (30); leg III, 22 (24); leg IV, 21 (22). *Segment lengths.* Tr I, 17 (15); tita I, 25 (24); ta II, 39 (37); tr IV, 20 (19); fege IV, 4 (5); ta IV, 55 (55). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 11T + 9S; leg II: cx 1T, tr 3T, ti 4T + 1S, ta 5T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 5T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tarsi II and III conical and elongate; all but one sensory seta of tibiotarsus I setiform or rodlike, the exception lateral, clavate; solenidium of tarsus II large and bullet-shaped, bearing apical prickle; the two setae of trochanter IV and two of tibia IV subequal in width, greatly enlarged, wider than any other setae of leg.

HABITS. Nothing is known of the habits of this species.

DISTRIBUTION. Known only from the type locality.

TYPE MATERIAL. Female holotype and one female paratype from The University of Kansas Natural History Reservation, Lawrence, Kansas, April 10, 1957, C. W. Rettenmeyer, from body of *Neivamyrmex opacithorax* (Emery).

TYPE REPOSITORIES. Holotype and single paratype in Snow Entomological Museum, The University of Kansas.

OTHER SPECIMENS EXAMINED. KANSAS: Lawrence, 1 ♀ from *Neivamyrmex nigrescens* (Cresson).

Perperipes, new genus

(Figs. 8-9, 75-77)

Type, *Perperipes ornithocephala*, new species.

This myrmecophilous genus is erected to accommodate three closely related forms apparently restricted to Central American doryline ants. The three forms concerned are separable only in relatively minor size and setal differences.

Upon superficial examination, they resemble scutacarid mites quite closely and are the members of the family Pyemotidate most likely to be misplaced into that family. In reality, *Perperipes* is most closely related to the microdispine genus *Glyphidomastax*, resembling that genus in the shape and placement of the peritremes, in the structure of the esophagus, in the conformation of the palpi and reduction of the chelicerae, in the structure of the esophageal "finned" structure, in the modified basal setae of tarsi II and III, and in the enlargement of the first hysterosomal segment. It differs from *Glyphidomastax* in body shape and in numerous other structural modifications. The genus is typically microdispine in possessing but one pair of dorsal propodosomal setae and two pairs of setae on segment V, in that the gnathosoma is elongate and because seta *c* of trochanter I is unmodified. It resembles members of the family Scutacaridae in body shape, in having an enlarged first hysterosomal segment which completely covers the propodosoma and which projects slightly over the base of the gnathosoma

and the basal segments of legs I and II, and whose margins are free anteriorly and laterally, as well as in the modification of legs IV. The genus differs from all or most scutacarids in that seta *c* of trochanter I is unmodified, in that the seta of coxa IV is basal rather than lateral, because the posterior genital sclerite is not definitely triangular in outline, in the shape and location of the stigmata, because the external presternals arise from apodemes IV, in that the propodosomal dorsum bears only one pair of setae, because segment V has only two pairs of setae, because pretarsus IV is not elongate, in lacking pinnacula on tibiotarsus I, in the shape of the propodosoma, and because females become enormously physogastric when gravid.

Both gravid and non-gravid females are known.

Diagnosis. Non-gravid females separable from those of all other pyemotid genera because the body is circular or sublimuloid in dorsoventral aspect. Further separable from all genera except *Glyphidomastax* in that tarsi II and III each possess a pair of greatly enlarged, subrectangulate basal setae and because the gnathosoma is greatly elongated, the palps fitted for piercing. Gravid females differ from those of other known genera in that the physogastric hysterosoma becomes elongate-cylindrical, possessing pseudosegments (see p. 61).

Description of Non-gravid Female. Length, 200 to 250μ; width, 200 to 215μ; width between anterior sternocoxal condyles of coxae III, 90 to 100μ; hysterosoma broadly ovate, mites nearly circular or circular-limuloid as seen in dorsoventral aspect; posterior margin of first hysterosomal segment lacking broad teeth; body well sclerotized, without scalelike or "pebbled" integumental markings, not striate on most lateral portions of posterior ventral plate but heavily and finely punctate.

Gnathosoma. Greatly elongate and much longer than wide, resembling skull of bird; palps distinct, greatly elongate, comprising about three-fourths length of gnathosoma, bladelike, simple, lacking distinct apical teeth; cheliceral bases distinct, converging apically, but blades degenerate and not fitted for piercing; bucca well defined; esophagus plainly visible as simple, thick, straight tube, not spiralled or coiled within a membranous pouch.

Propodosoma. Dorsum. Outline indistinct and variable depending upon mount but much broader than long, anterior margin more or less evenly rounded, prolonged hoodlike over gnathosoma, fora-

men ventral but only weakly sclerotized, not forming distinct collar; posterior margin indistinct; entire dorsum covered by first hysterosomal tergum; one pair of proposodsomal setae arising laterad of pseudostigmata; peritremes in anterior third, large, ovoid, widely separated, opening near anterodorsal angles of propodosoma, often appearing to open in propodosomal "shoulders," depending upon mount; esophageal "finned" structures characteristic, the middle one much the largest, its "fins" uneven and crooked, the anterior one "bow-tie" shaped, distinctly longer than the posterior one. *Venter.* Ventrals I not nearly in a transverse line; internal ventrals II well anterior to external ventrals II and much closer to them than to anterior median apodeme, both pairs approximate to coxal foramina II; secondary transverse suture lacking; anterior median apodeme moderately developed, complete; posterior portion of anterior ventral plate not elongate, distance between apodemes I and II only slightly less than that between apodemes II and posterior marginal apodemes; posterior marginal apodemes well developed, increasingly so laterally, mesal portions about same thickness as posterior median apodeme; pleated conjunctival band between propodosoma and hysterosoma indistinctly present dorsally.

Hysterosoma. Dorsum. First segment semicircular, expanded laterally and anteriorly, completely covering propodosomal dorsum and projecting slightly beyond, its free periphery with narrow band of indistinct radial striae; fifth segment bearing two pairs of ventral setae; vulva apicoventral, usually distinct; apical portion of vagina well sclerotized but not surrounded by apical, sclerotized, elliptical to globose pumplike enlargement; posterior genital sclerite well internal, small, irregular or crescent-shaped; two anterior genital sclerites present, the anteriormost broadly omega-shaped, the other irregular. *Venter.* Posterior ventral plate not elongated anteriorly, bearing six pairs of setae, its hind margin entire; external presternals well posterior to and slightly mesad of internal presternals, arising from apodemes IV; external poststernals present, arising adjacent to posterior sclerotization of coxal foramina IV; apodemes III only weakly present; apodemes IV well developed, complete, arcuate, joining coxae III near anterior sternocoxal condyles, meeting posterior median apodeme on level with line drawn between centers of coxal foramina III; posterior median apodeme arising anteriorly between internal presternals, often falsely appearing to be a posterior

prolongation of anterior median apodeme; posterior ventral plate laterad of legs without distinct striae or integumental pleats, but thick band of lateral conjunctival pleats present, sometimes indistinct; thick bands of opisthosomal conjunctival pleats also present ventrally beneath opisthosomal venter and dorsally between segments III and IV and between IV and V; opisthosoma as long as or slightly shorter than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV; opisthosomal venter lacking scalelike integumental engravings.

Legs. Short and stout, leg IV reduced; leg I distinctly shorter than gnathosoma, thinner than leg II; tibiotarsus I subquadrate, not wider than femurogenu I, lacking distinct pinnacula and mediolateral sclerotized area; claw I medium-sized, borne on thick pedicel, pedicel with distinct thumb; seta *e* of trochanter I stout and bladelike, at least twice width of other setae of leg; tarsi II and III each with four normal tactiles and two enormous basal tactiles, the latter sclerotized, rectangulate to clavate, serrate or armed with a prickle apically; solenidia of tibiae II and III present, arising at base of segment; pretarsi short, one-quarter the length of tarsi or less; claws II and III stout, with distinct basal dilation, claws IV lacking; pulvilli II and III extending distinctly beyond claws; coxa III elongate-subcordate in ventral aspect; coxa IV subquadrate; trochanter IV about half the length of coxa IV; femurogenu IV greatly reduced, bandlike, bearing one seta; tarsus IV greatly reduced, subequal to or shorter than tarsus III, not or only slightly attenuate; ratio of femurogenu IV to tarsus IV, 1:3.5 to 1:5.7.

Description of Gravid Female. As described for non-gravid female except for the following: physogastric, shape greatly elongate, cylindrical or slightly clavate posteriorly, resembling small insect larva; length, 1000 to 1300μ, width, 220 to 300μ at widest point; venter to and including ventral insertions of the third tergosternal muscles, and dorsum up to and including second dorsal segment bulbose, slightly dilated, lightly sclerotized, resembling head capsule of larval insect, this area sometimes set off by a sclerotized band delimiting its posterior margin; body behind above region with series of seven to nine regularly spaced conjunctival pseudosegments, true dorsal segments three and four located in depressions between these pseudosegments; two to three pseudosegments between true dorsal segments II and III, three between III and IV, one to three plus terminal lobe posterior to dorsal seg-

ment IV; segment V located ventrally on terminal lobe; all pseudosegments, with occasional exception of terminal lobe, with one or more rows of spicules at least laterally, or spicules indistinct or absent; if present, spicules often of two distinct sizes, coarser most frequent on anteriormost and posteriormost pseudosegments but present ventrally on all pseudosegments, finer most common dorsally and on sides of middle pseudosegments; vagina between anterior and posterior vaginal sclerites well defined, forming a birth pore which appears as a posterior linear prolongation of posterior median apodeme when viewed in ventral aspect; ventral conjunctival pseudosternum surrounding vagina (oviporal plate) distinctly convex when viewed in profile.

HABITS. A more lengthy discussion of the habits of these mites will be published by C. W. Rettenmeyer of Kansas State University in a forthcoming paper concerned with the inquilines and parasites of Central American doryline ants. Certain aspects not stressed by that author and certain conclusions drawn from studies of comparative morphology and phylogeny of the species will be presented here.

A feature of members of the genus shared only with *Glyphidomastax* is found in the mouthparts. In these two genera the normally styliform chelicerae are vestigial, their functions almost certainly being assumed by the elongated and bladelike palps. Since the latter are movable, they may be spread after penetration of the host tissue to insure a more stable attachment during engorgement.

The structure and conformation of the gravid female differs markedly in several respects from those described for more primitive forms such as *Pyemotes* and proceeds longitudinally so that the gravid mite resembles a tiny coleopterous or dipterous larva.

Gravid females are found only with the larval ants (C. W. Rettenmeyer, *in litt.*). Their food is not known, but it is probable that they are parasites of ant larvae or eggs in the same manner as the females of *Acarophenax tribolii* and its tenebrionid hosts. It seems less likely that they are merely trespassers competing for food with the host larvae. In either event, the adaptive value of the larval mimicry is obvious.

Young (*i. e.*, non-gravid) adult females are phoretic upon worker ants. Males are unknown.

In the manner of *Siteroptes*, eggs in various stages of cleavage are found within the body of the female, some containing well-developed larvae. In no cases, however, were other stages found therein, which suggests that a free larval stage may occur. This inference is strengthened by the fact that the most highly developed larval embryos are found in the region of the muscular common oviduct, through which they probably leave the body. Because of the presence of this structure and of the early embryos surrounding it, a complete hysterosomal breakdown resulting in the mass release of eggs or larvae probably does not occur. Dissection of three specimens indicates that the number of fully developed larvae present within the female at any one time is small, six to ten, while the total number of mature eggs may reach forty or more. Additional eggs in different, earlier stages of development are also easily seen.

If a free-living larval stage exists, this stage must be completed within or near the ant brood during the statary phase of the ants' cycle or shortly thereafter since the young females ride upon the worker ants.

Nymphal stage(s) are thought to be absent, the larva molting directly to the adult as in other specialized Pyemotidae and Scutacaridae.

Specimens Examined. In addition to the type species, as follows: Panama (Canal Zone): Barro Colorado Island, March 1-June 17, 1955, M. E. and C. W. Rettenmeyer, 50 non-gravid females from *Eciton burchelli* (Westwood) and *E. hamatum* (Fabricius). Same locality and collectors, August 7, 1956, 8 gravid females from *E. burchelli*. Same locality and collectors, May 18, 1956, 1 non-gravid female from *Nomamyrmex esenbecki crassicornis* (Smith). The author has included only specimens from *E. hamatum* in the description of the type species but is aware that later study may show the form from *E. burchelli* to be conspecific with it. The single female from *N. esenbecki* is undoubtedly specifically distinct.

Perperipes ornithocephala, new species

Description of Non-gravid Female. Length, 220μ (207-231, $\bar{X} = 220.46 \pm$ S. E. 1.83); width, 201μ (193-212, $\bar{X} = 203.20 \pm$ S. E. 1.94); distance between anterior sternocoxal condyles III, 96μ (96-99, $\bar{X} = 97.27 \pm$ S. E. 0.42).

Gnathosoma. Length, —[27] (55-59, $\bar{X} = 57.60 \pm$ S. E. 0.68); width, —[27] (24-26, $\bar{X} = 24.75 \pm$ S. E. 0.03); distance between pal-

27. This measurement not possible on holotype.

pal setae about 20μ; external dorsals tiny, setiform, arising posterolaterad of internal dorsals by areolar diameter of latter.

Propodosoma. Dorsum. Distance between internal pseudostigmatal sockets, 85μ (85-102, $\bar{X} = 91.80 \pm$ S. E. 1.55); propodosomal seta nude, distinctly shorter than pseudostigmatal pedicel. *Venter.* Setae moderate in size, 23 to 36μ long, flagellate, nude or sparsely plumose, internals I only slightly longer and wider than externals I; internal ventrals II well anterior to externals and only slightly mesad of them, straight line drawn between externals I and externals II passing barely laterad of internals II; apodemes II evenly arcuate, continuing laterally around anterior margin of coxal foramina II.

Hysterosoma. Dorsum. All dorsal setae sparsely plumose; setae of first segment subequally spaced, dorsals arising slightly anterior to laterals, 63μ (63-70, $\bar{X} = 66.92 \pm$ S. E. 0.71) apart, 22μ (21-25, $\bar{X} = 22.24 \pm$ S. E. 0.20) long, laterals about four times as long; dorsals II only slightly longer than dorsals I, 96μ (96-108, $\bar{X} = 100.24 \pm$ S. E. 0.72) apart, located approximately above center of coxae III; dorsals III 66μ (66-80, $\bar{X} = 76.41 \pm$ S. E. 0.87) apart, 41μ (39-50, $\bar{X} = 41.76 \pm$ S. E. 0.58) long; laterals III in nearly transverse line with dorsals, submarginal, 100μ (96-107, $\bar{X} = 102.77 \pm$ S. E. 1.22) long; setae of segment IV in transverse row, dorsals 52μ (46-59, $\bar{X} = 48.00 \pm$ S. E. 0.43) apart, 116μ (111-119, $\bar{X} = 116.13 \pm$ S. E. 0.43) long; laterals IV submarginal, 127μ (120-130, $\bar{X} = 125.60 \pm$ S. E. 0.83) long; setae of segment V distinctly ventral, internal caudal 79μ (73-85, $\bar{X} = 80.13 \pm$ S. E. 0.75) long, external caudals I lacking, external caudal II arising posterior to internal caudal and about the width of one setal base laterad to it, 39μ (36-41, $\bar{X} = 38.45 \pm$ S. E. 0.48) long. *Venter.* All setae of posterior ventral plate nude or nearly so, flagellate, about 9 to 33μ long; first axillary well laterad of anterior sternocoxal condyle of coxa III; second axillary located at posterior third of foraminal margin of coxa III; external presternal short, less than half the length of internal presternal; internal poststernal arising about half way between anterior median apodeme and external poststernal and behind inferior termination of posterior median apodeme; external poststernal extending slightly less than half way to posteriormost margin of opisthosoma; opisthosomal venter without scalelike engravings, its posterior margin entire.

Legs (all measurements in μ). *Length.* Leg I, 46 (46-47, $\bar{X} =$

46.54 ± S. E. 0.15); leg II, 80 (77-83, $\bar{X} = 79.07 \pm$ S. E. 0.50); leg III, 87 (77-88, $\bar{X} = 81.64 \pm 1.02$); leg IV, 85 (81-93, $\bar{X} = 85.31 \pm$ S. E. 0.70). *Width.* Leg I, 25 (15-28, $\bar{X} = 24.50 \pm$ S. E. 0.78); leg II, 37 (34-37, $\bar{X} = 36.00 \pm$ S. E. 0.26); leg III, 36 (35-39, $\bar{X} = 35.93 \pm$ S. E. 0.29); leg IV, 25 (24-29, $\bar{X} = 26.38 \pm$ S. E. 0.49). *Segment lengths.* Tr I, 19 (15-19, $\bar{X} = 16.38$); tita I, 20 (20-24, $\bar{X} = 22.19 \pm$ S. E. 0.25); ta II, 33 (29-33, $\bar{X} = 30.63 \pm 0.16$); ti III, 14 (14-17, $\bar{X} = 14.75 \pm$ S. E. 0.19); ta III, 33 (29-35, $\bar{X} = 31.57 \pm$ S. E. 0.44); cx IV, 33 (30-36, $\bar{X} = 33.19 \pm$ S. E. 0.42); tr IV, 14 (14-18, $\bar{X} = 15.25 \pm$ S. E. 0.23); fege IV, 3 (3-8, $\bar{X} = 6.29 \pm$ S. E. 0.38); ta IV, 28 (24-30, $\bar{X} = 26.88 \pm$ S. E. 0.59). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 13T + 7S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4 T+ 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T, ta 6T (only 3-5 usually visible).

Tibiotarsus I with four lateral clavate or bullet-shaped setae; solenidia of tibiae and tarsi II and III basal, often appearing to arise from preceding segments; solenidium of tarsus II moderately sized, clavate; anterior, enlarged, basal tactile with one large, median, apical tooth and two, tiny, pricklelike lateral teeth (or only large median tooth present); apex of posterior enlarged basal tactile seta similar, this seta not markedly clavate; coxa IV not bulbose basally; femurogenu IV bandlike, appearing only wide enough to bear stout seta; other segments of leg IV bearing very stout setae of which the external of the trochanter and the external of the tibia are longest, about 150μ; ventromedial seta of tibia IV nearly as broad but much shorter, about 105μ.

Distribution. Known only from the Republic of Panamá.

Type Material. Female holotype and sixteen female paratypes (none gravid) from Barro Colorado Island, Canal Zone, Panamá, June 16, 1956, C. W. and M. E. Rettenmeyer, from *Eciton hamatum*, Colony No. E-189.

Type Repositories. Holotype and twelve paratypes (nos. 3 to 14) in the Snow Entomological Museum, The University of Kansas. One paratype (no. 1) in the U. S. National Museum. One paratype, (no. 15) in the Zoologische Institut, Universität Erlangen, Erlangen, Germany, one paratype (no. 16) in the British Museum (Natural History), London, England, and one paratype (no. 2) in the private collection of C. W. Rettenmeyer, Kansas State University, Manhattan, Kansas.

SPECIMENS EXAMINED. PANAMA: Same data as type series, nine females. Pieer River, Darien Province, February 16, 1948, T. C. Schneirla, from *Eciton hamatum* in nomadic day 2 (Colony No. 148HD), 24 gravid females.

Neopygmephorini, new tribe

This tribe includes four genera whose interrelationships are unclear. Three of these groups seemingly possess no entirely unique characters and are therefore difficult to characterize although group differences are obvious upon careful inspection. The fourth genus, *Acinogaster,* is easily distinguishable from the others although it is more closely related to (and is probably an "exgroup" of) *Parapygmephorus* than any of the other genera are to each other.

Members of the tribe are thought to be among the most highly specialized forms of the Pyemotidae and to be ancestral to the family Scutacaridae.

DIAGNOSIS. Females easily separable from those of other Pygmephorinae in that seta *c* is always modified bladelike, its apex often proflexed, and in having one or (usually) two but never three pairs of propodosomal dorsals.

DESCRIPTION OF NON-GRAVID FEMALE. *Gnathosoma.* Usually quadrate, occasionally longer than wide; palps palmate to subpalmate, with one or more distinct apical teeth, never greatly elongate, not fitted for piercing; ventral esophageal-pharyngeal pump absent; chelicerae distinct or not, if so then small, aciculate; esophagus not distinctly coiled between pharynx and esophageal "finned structures."

Propodosoma. Dorsum. With one (rarely) or two pairs of setae, if two pairs, both distinctly visible; peritremes widely separated, usually circular, rarely elongate or guttate; esophageal "finned" structures distinct or not, varying in number. *Venter.* Anterior ventral plate with four pairs of setae; external ventrals I furcate or not.

Hysterosoma. Dorsum. First hysterosomal tergum enlarged anteriorly to cover entire propodosomal dorsum or (usually) not, if so, then margins neither projecting free nor with radial striations; segment V with two (rarely) or three pairs of setae; posterior portion of vaginal wall often sclerotized but lacking globose to elliptical pumplike enlargements; posterior genital sclerite usually triangular

and flaplike, often broadly so. *Venter.* Posterior ventral plate entire, its hind margin rarely tripartite; apodemes V absent.

Legs. Leg I articulated obliquely (usually) or at a right angle to the longitudinal axis of body, size variable; claw I usually present, only rarely sessile (in some *Sicilipes*); mediolateral sclerotized area of tibiotarsus I usually present; trochanter I with three setae, seta *c* semimembranous, bladelike, its apex usually distinctly proflexed; piannacula of tibiotarsus I present or absent.

Key to the Genera of the Tribe Neopygmephorini (Females)

1(*a*). First and second axillaries and internal ventrals I and II greatly enlarged, compressed, variously clavate to acuminate
Acinogaster, new genus, p. 214

1(*b*). First and second axillaries and internal ventrals I and II setiform....2

2(*a*). Coxa IV broadly constricted about two-thirds of distance from apex, base rounded, bulbose, or, if (rarely) constriction not distinct, then legs long and thin, trochanter IV at least 2.5 times as long as wide (if less than 2.7 times, then trochanter III at least 2.5 times as long as wide); leg I thinner,[28] usually shorter than leg II
Neopygmephorus, new genus, p. 225

2(*b*). Coxa IV only rarely constricted and bulbose basally, if so then claw I sessile or leg I at least as wide as leg II.....3

3(*a*). With the following combination of characters: leg I at least as wide as leg II; longitudinal distance between internal presternal and external presternal always equal to or greater than transverse distance between external presternal and first axillary
Pseudopygmephorus, new genus, p. 221

3(*b*). Leg I usually distinctly thinner and shorter than leg II, if as wide then longitudinal distance between internal presternal and external presternal distinctly less than transverse distance between external presternal and first axillary.....*Parapygmephorus*, new genus, p. 197

28. As measured at apex of trochanter.

Parapygmephorus, new genus

This genus contains a number of morphologically heterogeneous but intergrading forms, the most primitive of which resemble closely and are presumably closely related to *Pygmephorus.* More specialized forms (*Parapygmephorus s. str.*) closely resemble *Neopygmephorus.* In this paper, the latter genus is considered to be an "exgroup" of *Pseudopygmephorus* for reasons stated elsewhere, and the many morphological similarities between *Parapygmephorus* and *Neopygmephorus* are considered to have been derived independently. The arrangement of apodemes IV and of the external presternals, the shape and size of the stigmata, and the occasional presence in both groups of characters universal to the other are instances of such parallelism.

Ecologically, species of *Parapygmephorus* tend to differ from those of *Neopygmephorus,* being usually associated with Hymenoptera, although one form in the author's collection is found with termites and several species are recorded from decayed wood or sphagnum. It is possible that the latter were dislodged from insects during the processes of collecting and sorting.

The genus is here divided into three subgenera, of which *Sicilipes* is considered the most primitive and *Petalomium* the most specialized. Only the females are known.

DIAGNOSIS. Females may be separated from those of *Pseudopygmephorus* because the longitudinal distance between the internal and the external presternal is distinctly less than that between the external presternal and the first axillary. In addition, leg I is shorter and usually thinner than leg II. If (rarely) it is as wide, then claw I is enlarged, opposed by a stout thumb, and tibiotarsus I has a distinct, circular, dorsal, mediolateral sclerotized area. They are distinguished from those of *Neopygmephorus* in that coxa IV is not distinctly constricted at its basal third, or if so, then claw I is sessile.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 130 to 430μ; width, 70 to 240μ; width between anterior sternocoxal condyles III, 55 to 140μ; hysterosoma ovate, sometimes broadly so; body very weakly to heavily sclerotized, rarely with scalelike integumental engravings; coarse punctae and striae usually absent on most lateral portions of posterior ventral plate.

Gnathosoma. Variously shaped, normally directed ventrally or posteroventrally; solenidium II usually greatly enlarged.

Propodosoma. Dorsum. Inversely T-shaped to broadly trapezoidal; anterior portion of dorsum prolonged hoodlike over gnathosoma, lateral margins of circumgnathosomal foramen thickened to form collar or not; posterior one-fourth to posterior three-fourths covered by first hysterosomal tergum; pseudostigmata located in posterior half; two pairs of propodosomal setae; peritremes large and circular or smaller, transversely ovoid, their mesal margins usually broken or emarginate because of stigmatal openings; peritremes located in anterior two-thirds of propodosoma or, rarely, in propodosomal "shoulders"; esophageal "finned" structures distinct or not visible, if distinct, then fins erect, close together. *Venter.* Internal ventral I arising anterior or posterior to external ventral I; internal ventral II not to distinctly anterior to external ventral II

and much closer to it than to anterior median apodeme; external ventrals I forked or not; coxa I articulating at nearly a right angle to the longitudinal axis of body or (usually) distinctly obliquely; apodemes II variable, absent to strongly developed, usually incomplete, strongly arcuate or slightly W-shaped if present; secondary transverse apodeme present or absent, if present, then usually distinct only at sides and continued as thickening mesally; anterior median apodeme weakly to strongly developed, complete or not; posterior marginal apodemes straight, gently arcuate, or lyrate, usually strong, especially at the sides; distinct, pleated conjunctival band present or absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment overlapping posterior one-fourth to posterior three-fourths of propodosoma; fifth segment with three pairs of setae, these apical or apicoventral, or occasionally one pair well ventral; vulva apical or apicoventral; vagina enclosed apically by sclerotized, globose to elliptical pumplike enlargement or vagina merely sclerotized apically or soft and indistinct; posterior genital sclerite varying, irregular to triangular and flaplike in shape; median genital sclerite present or not. *Venter.* Posterior ventral plate with six pairs of setae, its hind margin entire, straight, broadly emarginate, or rarely trilobate; position of external presternals variable; external poststernals present, always arising from or close behind (at most half basal width of coxa IV, usually less) posteromesal sclerotization of fourth coxal foramina; apodemes III and IV variable in structure and definition; posterior median apodeme variable in extent and definition; band of opisthosomal conjunctival pleats usually absent, rarely well developed; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV; opisthosomal venter lacking integumental engravings.

Legs. Legs elongate or not, usually quite stout, ratio of length to width of trochanter IV, 1:1.2 to 1:3.0, rarely over 1:2.5; leg I distinctly shorter and usually thinner than leg II; tibiotarsus I usually elongate, about one and one-half times to twice as long as wide, distinctly wider than femurogenu I or not; pinnacula present or absent; mediolateral sclerotized area present or not, if present varying in shape and location; claw I dilate basally, variable in size, sessile (rarely) or pedicellate, pedicel usually broad and constricted basally, if present; thumb variable in size; apical portion of seta *c* of trochanter I proflexed or not; tarsi II and III each with six

tactiles; solenidia of tibiae II and III present; pretarsus IV usually short, rarely a third as long as tarsus IV; claws II and III with large basal dilations, claw IV simple, usually reduced; pulvilli II to IV well developed, at least slightly longer than claws; coxa III elongate-subcordate to subcordate as viewed in inner ventral aspect, distance between anterior and posterior sternocoxal articulations 22 to 42μ; coxa IV short-rectangulate to rectangulate, basal third not to (rarely) distinctly constricted, basal fifth not to (rarely) distinctly bulbose, if distinctly constricted and bulbose then claw I sessile; ratio, length to width of coxa IV, 1:1.3 to 1:2.3, usually between 1:1.8 and 1:2.0; trochanter IV usually shorter than coxa IV; tarsus IV always distinctly longer than tarsus III, usually elongate and rather evenly attenuate, if short, then constricted abruptly basad of pretarsus; ratio of femurogenu IV to tarsus IV 1:2.9 to 1:10.5.

Key to the Subgenera of *Parapygmephorus* (Females)

1(*a*). External ventrals I of anterior ventral plate bi- or trifurcate; solenidium II arising from apex of tibia II; tibiotarsus I usually with distinct pinnaculum which is at least twice as long as wide
Petalomium, new subgenus, p. 209

1(*b*). External ventrals I of anterior ventral plate not furcate; solenidium II rarely on apex of tibia II, usually in normal position or (rarely) arising from tibiotarsal conjunctiva; tibiotarsus I lacking pinnaculum which is at least twice as long as wide.....2

2(*a*). Tibiotarsus I always distinctly wider than femurogenu I, with dorsal, circular, mediolateral sclerotized plate; claw I moderate to large, sessile or borne on short pedicel which is as wide or wider than long; external presternals arising from apodomes IV or nearly so; secondary transverse suture of anterior ventral plate absent
Sicilipes, new subgenus, p. 200

2(*b*). Tibiotarsus I usually not or only slightly wider than femurogenu I, usually lacking dorsal, circular, mediolateral sclerotized plate—if distinctly wider and plate dorsal and circular, then either external presternals arising well anterior to apodemes IV or secondary transverse suture of anterior ventral plate present; claw I small to moderate, borne on pedicel which is as long or longer than wide
Parapygmephorus, sensu stricto, p. 205

Sicilipes, new subgenus

(Figs. 81-83)

Type, *Parapygmephorus* (*Sicilipes*) *halictinis*, new species.

This subgenus seemingly stands phylogenetically between *Pygmephorus* and *Parapygmephorus, s. str.*, and, with certain *Pseudopygmephorus*, is considered to contain the least specialized forms in the tribe Neopygmephorini.

Three undescribed species have been seen, two of which are phoretic upon bees. The third is found in woodland leaf litter. Only the non-gravid females are known.

Diagnosis. Females easily separable from those of *Petalomium* in lacking pinnacula, because the tarsal solenidium of leg II is basal, and because external ventrals I are not forked. They are separable from *Parapygmephorus* by the following combination of characters: tibiotarsus I distinctly wider than femurogenu I and possessing a dorsal, circular, mediolateral, sclerotized plate; external presternals arising from or barely in front of apodemes IV; secondary transverse suture of anterior ventral plate absent.

Description of Non-gravid Female. Length, 190 to 225μ; width, 115 to 130μ; width between anterior sternocoxal condyles III, 80 to 100μ.

Gnathosoma. Quadrate or distinctly broader than long.

Propodosoma. Dorsum. Inversely T-shaped; distance between internal pseudostigmatal sockets distinctly greater than length of propodosomal dorsum; foraminal collar distinct; posterior margin to posterior one fourth covered by first hysterosomal tergum; pseudostigmata located in posterior one fourth; peritremes without conspicuous rim, circular, widely separated, their mesal margins not distinctly emarginate, located in anterior half of dorsum or in propodosomal "shoulders"; if esophageal "finned" structures distinct, then posterior one enlarged, globose to elliptical, more prominent than elongate, cylindrical structure which precedes it, fins erect and straight, those of posterior structure much finer than those of anterior. *Venter.* Internal ventrals I arising anteriorly to external ventrals I; internal ventrals II only slightly anterior to external ventrals II, slightly to distinctly closer to them than to anterior median apodeme; external ventrals I not furcate; apodemes II weak or absent, if present, arcuate and usually complete; secondary transverse apodeme absent; anterior median apodeme usually strongly developed, complete; posterior marginal apodeme straight or nearly so.

Hysterosoma. Dorsum. First segment overlapping posterior margin to posterior one fourth of propodosomal dorsum; vulva apical; apical wall of vagina often distinctly sclerotized; posterior genital sclerite variously shaped but never triangular and flaplike; median genital sclerite absent. *Venter.* Hind margin of posterior ventral plate usually broadly emarginate; external presternals always arising from apodemes IV or less than one areolar diameter in front of them; apodemes III distinct or not, if distinct usually recurved at the sides to join anterior margins of coxal foramina III;

apodemes IV weakly to strongly developed, directed toward or joining coxal foramina III either at top quarter or recurving posteriorly to meet margin behind center; apodemes IV joining posterior median apodeme on or behind line drawn between anterior quarters of coxal foramina III; portion of posterior median apodeme behind apodemes IV about as long as or slightly longer than portion anterior to apodemes IV.

Legs. Ratio of length to width of trochanter IV, 1:2.1 to 1:2.4; leg I thinner than or as wide as leg II; tibiotarsus I usually about one and one-half times as long as wide, always much wider than femurogenu I; pinnacula absent; mediolateral sensory area present, enlarged and circular dorsally; claw I moderate to large in size, if pedicellate, pedicel as wide as or wider than long; thumb moderately to greatly enlarged; apical portion of seta *c* of trochanter I sharply proflexed; basal solenidium of tarsus II in normal position; pretarsus IV never nearly a third the length of tarsus IV; coxa IV subcordate when viewed in inner ventral aspect, distance between anterior and posterior sternocoxal articulations 22 to 30μ; trochanter IV subequal to coxa IV in length; tarsus IV moderately elongate, stout basally, tapering evenly to pretarsus or becoming suddenly constricted in apical half; ratio of femurogenu IV to tarsus IV, 1:3.5 to 1:5.0.

HABITS. Nothing is known of the habits of these mites.

SPECIMENS EXAMINED. In addition to the type species, as follows: *Species No. 1.* Highlands Hammock State Park, Florida, 1 ♀, leaf litter in low woods (berlese sample). *Species No. 2.* Moctezuma, Chihuahua, Mexico, 3 ♀ ♀ from thorax of ♀ *Agapostemon* sp. (Apoidea).

Parapygmephorus (*Sicilipes*) *halictinis,* new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 220μ (210-220, $\bar{X} = 215.86$); width, 131μ (115-131, $\bar{X} = 126.85$); distance between anterior sternocoxal condyles III, 85μ (85-88, $\bar{X} = 86.40$); body well sclerotized, coarsely punctate, punctae most noticeable on entire hysterosomal dorsum and opisthosomal venter, discs of terga I to III with jagged, shingled engravings besides.

Gnathosoma. Length, 25μ (22-25, $\bar{X} = 23.40$); width, 28μ (23-28, $\bar{X} = 24.17$); external dorsals less than half as long as internals, well posterior to and slightly laterad of them; anterior and posterior palpal setae only three to four μ apart; palp with single, greatly enlarged, mesally directed apicoventral tooth; palpal solenidium II greatly enlarged, cylindrical, solenidium I tiny, acuminate.

Propodosoma. Dorsum. Inversely T-shaped, anteriormost portion distinctly bulbose; peritremes circular, dorsal, located in anterior one quarter; distance between internal pseudostigmatal sockets 48μ (44-52, $\bar{X} = 47.14$); anterior pseudostigmatal seta short, nude, 16μ (11-16, $\bar{X} = 14.50$), arising immediately anteromesad of external pseudostigmatal socket, posterior pseudostigmatal seta arising posteromesad, very long, 63μ (57-63, $\bar{X} = 58.00$), sparsely plumose. *Venter.* All setae flagellate, sparsely plumose, 33 to 46μ long; internal ventral II longer than external II, only slightly anterior to it; lateral and ventral margins of circumgnathosomal foramen greatly thickened, forming a distinct gnathosomal collar; apodemes II absent or indistinct.

Hysterosoma. Dorsum. All dorsal setae stout, long, sparsely plumose; setae of first segment in transverse row or nearly so, dorsals 41μ (41-47, $\bar{X} = 42.50$) long, 52μ (52-57, $\bar{X} = 54.29$) apart; laterals I 88μ (85-93, $\bar{X} = 87.83$) long, much closer to respective dorsals than dorsals to each other; dorsals II separated by one of their own lengths, 47μ (42-51, $\bar{X} = 46.57$) long; dorsals III arising approximately directly behind dorsals II, 50μ (48-53, $\bar{X} = 50.71$) long, laterals III about two areolar diameters posterolaterad, more slender than but about as long as dorsals; dorsals IV 60μ (57-62, $\bar{X} = 59.57$) long, only 19μ (19-22, $\bar{X} = 20.43$) apart, laterals IV nearly that same distance posterolaterad, subequal in length to dorsals; setae of segment V thin, flagellate, sparsely plumose, arising distinctly from the venter, internal caudals shortest, 19μ (17-20, $\bar{X} = 18.14$) long, arising well anteromesad of external caudals; external caudals I 28μ (25-31, $\bar{X} = 27.86$) long, much closer to internal caudals than to external caudals II and subequal to or slightly longer than the latter. *Venter.* All setae of posterior ventral plate flagellate, 20μ (1st axillaries) to 50μ (external poststernals) long; first axillaries barely anterior of line drawn between anteriormost margins of coxal foramina III, nearly in transverse line with internal presternals; external presternals well behind and distinctly mesad of internal presternals; external poststernals arising distinctly anteriorly to line drawn between posteromesal margins of coxal foramina IV; apodemes III indistinct; apodemes IV indistinct or distinct only laterally, joining coxal foramina behind middle; posterior margin of opisthosomal venter broadly and shallowly emarginate (to broadly rounded).

Legs (all measurements in μ). *Length.* Leg I, 55 (54-57, $\bar{X} = 55.43$); leg II, 69 (64-70, $\bar{X} = 68.17$); leg III, 74 (70-85, $\bar{X} = 75.17$); leg IV, 126 (118-128, $\bar{X} = 124.86$). *Width.* Leg I, 19 (15-19,

$\bar{X} = 17.14$); leg II, 19 (14-19, $\bar{X} = 17.43$); leg III, 17 (13-17, $\bar{X} = 14.43$); leg IV, 15 (13-15, $\bar{X} = 13.86$). *Segment lengths.* Tr I, 21 (19-21, $\bar{X} = 20.14$); tita I, 24 (24-28, $\bar{X} = 25.71$); tr II, 24 (23-24, $\bar{X} = 23.71$); ta II, 25 (22-25, $\bar{X} = 23.67$); tr III, 24 (24-28, $\bar{X} = 26.57$); ti III, 13 (13-14, $\bar{X} = 13.29$); ta III, 26 (25-28), $\bar{X} = 26.20$); cx IV, 29 (25-30, $\bar{X} = 28.00$); tr IV, 26 (26-30, $\bar{X} = 28.29$); fege IV, 12 (9-12, $\bar{X} = 10.29$); ta IV, 41 (37-42, $\bar{X} = 40.86$). *Setation.* Leg I: cx 1T, tr 1T + 2 modified, fege 4T, tita 12T + 8S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Seta *c* of trochanter I sharply proflexed, seta *d* longer but bladelike, undulate; solenidium 3 of tibiotarsus I short, acuminate, solenidium 4 laterad of it, less than a third as long, clavate; tibial solenidia of legs II and III arising from basal third, small, clavate; tarsal solenidium of leg II resembling solenidium 3 of first leg but smaller; coxa IV short-rectangulate, evenly dilate toward the base, ratio of length to width 1:1.3 to 1:1.6; tarsus IV constricted abruptly in apical half; ratio of femurogenu IV to tarsus IV 1:3.4 to 1:4.7; claw IV simple but well developed, not greatly smaller than claw III.

HABITS. Nothing is known of the habits of this species. The non-gravid females are found, often in huge masses, on the anterior face of the first metasomal tergum of the halictine bee *Agapostemon virescens* (Fabricius). Occasional stragglers may be found on the discs of the metasomal terga, on the posterior face of the propodeum, in the mesothoracic spiracular openings, etc. It is probable, in consideration of the numbers of mites involved, that these are acquired by the bee while she is yet in the burrow.

DISTRIBUTION. Known only from Summit County, Ohio, and Tippecanoe County, Indiana.

TYPE MATERIAL. Female holotype from Summit County, Ohio, July 3, 1934, L. J. Lipovsky, from *Agapostemon virescens* (Fabricius). Five female paratypes (nos. 1-5) from Lafayette, Tippecanoe County, Indiana, July 5, 1932, collector unknown, from *Agapostemon virescens.*

TYPE REPOSITORIES. Holotype and two paratypes (nos. 1 and 3) in the Snow Entomological Museum, The University of Kansas, one paratype (no. 2) in the Purdue Entomological Collections, Purdue University, one paratype (no. 4) in the U. S. National Museum, Washington, D. C., and one paratype (no. 5) in the Zoologisches Institut, Universität Erlangen, Erlangen, Germany.

Specimens Examined. In addition to the type material as follows: Lafayette, Indiana, August 25, 1939, collector unknown, numerous females from *A. virescens*. Same, July 25, 1921, and September 28, 1921.

Subgenus *Parapygmephorus, sensu stricto*

(Figs. 87-89)

Type, *Paragymephorus* (*Parapygmephorus*) *natalensis*, new species.

This subgenus includes a rather heterogeneous group of forms, the largest division of which is phoretic upon and perhaps parasitic upon certain African and Asian species of the apoid subfamily Nomiinae. Other species are associated with other halictine bees, with termites, and with ants. Members of the subgenus exhibit fewer specialized characters than do those of the subgenus *Petalomium* and are most closely related to members of the subgenus *Sicilipes*.

Diagnosis. Females separable from those of *Sicilipes* and *Petalomium* by the characters given in the subgeneric key.

Description of Non-gravid Female. Length, 130 to 430μ; width, 70 to 240μ; distance between anterior sternocoxal condyles III, 55 to 125μ; body often with coarse punctae; hysterosomal dorsum occasionally with scalelike integumental engravings.

Gnathosoma. Quadrate to distinctly longer than wide; palpal solenidium II usually clavate; esophagus usually distinct, occasionally with small "bow-tie" finned structure.

Propodosoma. Dorsum. Inversely T-shaped to nearly rectangulate, usually poorly developed behind pseudostigmatal sockets; distance between internal pseudostigmatal sockets usually slightly less than, rarely more than length of propodosoma; foramen usually anteroventrad, rarely ventrad, foraminal collar usually distinct laterally; pseudostigmata located in posterior third; peritremes circular, rarely somewhat ovoid, located in middle third of dorsum; from one to three "finned" structures usually distinct,[29] if so then posterior one subglobose, not enlarged or more prominent than one preceding, latter elongate, often greatly so. *Venter.* Internal ventrals I usually arising distinctly anterior to, rarely posterior to external ventrals I; internal ventrals II slightly to distinctly anterior to external ventrals II; external ventrals I not furcate; coxa I attached at an oblique angle to longitudinal axis of body; anterior median apodeme usually strongly developed and complete.

29. If three present, one usually in gnathosoma, two in propodosoma.

Hysterosoma. Dorsum. First segment overlapping posterior one fourth to one third of propodosoma; setae of fifth segment apical or apicoventral; vulva usually enclosed in genital sulcus; apical portion of vaginal wall usually sclerotized, sometimes thickly so. *Venter.* Hind margin of posterior ventral plate straight, broadly emarginate, undulate, or rounded; external presternals arising on to well anterior of apodemes IV; distance between external presternals always greater than that between internal presternals; external poststernals arising half the basal width of coxa IV or less behind line drawn between posteromesal margins of coxal foramina IV; apodemes III indistinct to distinct, curving posteriorly at the sides to join anterior sternocoxal condyles of coxae III or not; apodemes IV usually joining, always extending at least three-quarters of distance to coxal foramina III; apodemes IV directed toward or joining margins of coxal foramina III at varying points, joining posterior median apodeme on or anterior to line drawn between centers of coxal foramina III; portion of posterior median apodeme behind apodemes IV about four-fifths to one and three-quarters times as long as that anterior to apodemes IV.

Legs. Leg I distinctly shorter and thinner than leg II; tibiotarsus I variable in length, usually about twice as long as wide, as wide as or distinctly wider than femurogenu I; pinnacula absent or reduced, height never nearly twice apical width; mediolateral sclerotized plate variously developed, indistinct, irregular and marginal, or becoming enlarged and circular dorsally; claw I moderate to large in size, pedicellate, pedicel usually about as long as wide; thumb weakly to strongly developed; apical portion of seta *c* of trochanter I usually strongly proflexed; tarsal solenidium of leg II usually arising from base of tarsus but occasionally from tibiotarsal conjunctiva or from tibial apex; pretarsus IV never nearly a third the length of the tarsus; basal third of coxa IV not or only slightly constricted, not or only weakly bulbose basally; ratio of length to width of coxa IV, 1:1.3 to 1:2.1; ratio of femurogenu IV to tarsus IV, 1:2.9 to 1:6.8.

Species thought to belong in *Parapygmephorus, s. str.:*

?*chaetosus* (Krczal, 1959) (*Pygmephorus*)

HABITS. Nothing is known of the habits of the species included herein. To judge by the presence of bands of pleated conjunctiva, extreme physogastry may occur in at least two species associated with bees. Host preferences are similar to those of the other sub-

genera, five of the ten species seen by the author being from bees, two from ants, one from termites, one from decayed wood, and one from "under rock."

Specimens Examined. In addition to the type series as follows: nine species from the central United States and from Brazil, Panamá, Mexico (San Luis Potosí), Phillippines (Luzon), and Africa, from the following situations or hosts: *Neivamyrmex legionis* (F. Smith), *N. gibbatus* Borgmeier, *Nomamyrmex esenbecki* (Smith) (all Formicidae, Dorylinae), *Nomia* sp., *Nomia philippinensis* Cockerell, *Augochlora* sp. (all Apoidea, Halictidae), from under rock, in decayed wood, from workers of *Reticulitermes flavipes* (Kollar) (Isoptera).

Parapygmephorus (*Parapygmephorus*) *natalensis*, new species

Description of Non-gravid Female. Length, 270μ (257-282, $\bar{X} = 269$); width, 165μ (162-165, $\bar{X} = 164$); distance between anterior sternocoxal condyles III, 123μ (123-126, $\bar{X} = 125$); body moderately sclerotized, coarsely punctate, punctae most noticeable on propodosomal dorsum and especially on discs of hysterosomal terga I to IV; other integumental markings absent.

Gnathosoma. Length, 37μ ($\bar{X} = 37$); width, 36μ (31-36, $\bar{X} = 34$); external dorsals about three-quarters as long as internals, distinctly more laterad of them than posterior to them; postpalpals spiniform, slightly anterior to internal and slightly laterad of external dorsals; anterior and posterior palpal setae about 5μ apart; palp with distinct apical inner tooth; palpal solenidium I clavate, about half as long as II.

Propodosoma. Dorsum. Inversely T-shaped, anteriormost portion distinctly bulbose; peritremes large, circular (or nearly so), dorsal, located about half way between anterior and posterior margins of propodosoma, rather indistinct; stigmatal openings more prominent than peritremes, guttate; distance between internal pseudostigmatal sockets 55μ (55-58, $\bar{X} = 56$); anterior pseudostigmatal setae nude, short, 11μ (11-12, $\bar{X} = 11$) long, well anteromesad of internal pseudostigmatal socket, posterior pseudostigmatals elongate, 62μ (62-69, $\bar{X} = 66$), sparsely plumose, arising on line drawn between internal pseudostigmatal sockets (or nearly so). *Venter.* All setae flagellate, sparsely plumose; ventrals I subsequal in size, about 35 to 40μ long; internal ventrals II elongate, about 58 to 63μ, externals II only about half as long, arising distinctly posterior to internals; lateral and ventral margins of circumgnathosomal foramen greatly

thickened, forming gnathosomal collar; apodemes II distinct, arcuate, terminating at point of origin of external ventrals I; secondary transverse apodemes present, meeting apodemes II medially.

Hysterosoma. Dorsum. All dorsal setae stout, elongate (some greatly so), sparsely plumose; setae of first segment in transverse row, dorsals 52μ (52-59, $\bar{X} = 56$) long, 63μ (63-68, $\bar{X} = 65$) apart; laterals I 163μ (160-163, $\bar{X} = 161$) long, much closer to respective dorsals than dorsals to each other; dorsals II 61μ (61-70, $\bar{X} = 67$) apart, 56μ (56-63, $\bar{X} = 59$) long; dorsals III arising nearly directly behind dorsals II, 63μ (63-75, $\bar{X} = 69$) apart, 143μ (143-157, $\bar{X} = 148$) long, laterals III arising about two areolar diameters posterolaterad, only 30μ (30-35, $\bar{X} = 32$) long; dorsals IV 97μ (79-105, $\bar{X} = 101$) long, only 43μ (43-48, $\bar{X} = 46$) apart, laterals IV barely anterior to and about three areolar diameters laterad of them, 74μ (74-83, $\bar{X} = 80$) long; setae of segment V much smaller than those of preceding segments, arising distinctly from ventral surface; internal caudals and external caudals I arising in transverse line, their areoli contiguous or nearly so; external caudals II about three areolar widths anteroventrad of internal caudals; length of internal caudals, 42μ (40-42, $\bar{X} = 41$), of external caudals I, 31μ ($\bar{X} = 31$), of external caudals II, 17μ (17-18, $\bar{X} = 18$). *Venter.* All setae of posterior ventral plate well developed, flagellate, 30 (internal presternals) to 48μ (external presternals) long; first axillary distinctly behind internal presternals but well anterior to line drawn between anteriormost margins of coxal foramina III; external presternals well behind and distinctly laterad of internal presternals, arising about one areolar diameter anterior to apodemes IV, external poststernals half the basal width of coxa IV behind line drawn between posteromesal margins of coxal foramina IV; apodemes III distinct, at right angles to longitudinal axis of body, extending laterad to longitude of first axillaries; apodemes IV distinct, joining mesal margins of coxal foramina III at or slightly behind their centers; distinct band of conjunctival pleats present (or band indistinct) ventrally beneath posterior ventral plate, dorsally between segments III and IV; vulvar sulcus present; posterior genital sclerite elongate, triangular and flaplike.

Legs (all measurements in μ). *Length.* Leg I, 91 (91); leg II, 129 ($\bar{X} = 129$); leg III, 144 (142-146, $\bar{X} = 144$); leg IV, 203 (201-203, $\bar{X} = 202$). *Width.* Leg I, 24 (23-25, $\bar{X} = 24$); leg II, 25 (25-30, $\bar{X} = 27$); leg III, 24 (24-25, $\bar{X} = 24$); leg IV, 16 (16-22, $\bar{X} = 19$). *Segment lengths.* Tr I, 21 (21-33, $\bar{X} = 26$); tita I, 47 ($\bar{X} = 47$); tr II, 44 (43-44, $\bar{X} = 44$); ta II, 48 (46-48, $\bar{X} = 47$);

tr III, 51 (51-54, $\bar{X} = 52$); ti III, 25 (24-25, $\bar{X} = 25$); ta III, 52 (50-55, $\bar{X} = 52$); cx IV, 46 (46-50, $\bar{X} = 47$); tr IV, 47 (44-49, $\bar{X} = 47$); fege IV, 17 (15-17, $\bar{X} = 16$); ta IV, 68 (67-68, $\bar{X} = 68$). *Setation.* Leg I: cx 1T, tr 2T + 1 modified, fege 4T, tita 11T + 9S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 1S, ta 6T + 1S; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Seta *c* of trochanter I sharply proflexed, seta *d* also short and bladelike; solenidium 3 of tibiotarsus I about nine μ, attenuate, apex rounded; solenidium 4 slightly more than half as along as 3, rodlike; solenidia 1 and 2 not over eight μ; tibiotarsus I elongate, slightly wider than femurogenu; tibial solenidia of legs II and III about five μ, weakly clavate, tarsal solenidium of leg II about seven μ, peglike; coxa IV rectangulate, ratio of length to width about 1:1.6 to 1:1.8; ratio, length to width of trochanter III about 1:2.1; tarsus IV evenly attenuate apically, 68μ (67-68, $\bar{X} = 68$) long; ratio of femurogenu IV to tarsus IV about 1:4.0 to 1:4.5; ratio, length to width of trochanter IV about 1:2.2 to 1:2.9.

Habits. Nothing is known of the habits of this species. The non-gravid females were taken from the body of the African nomiine bee *Crinoglossa natalensis* Friese.

Distribution. Known only from the type locality.

Type Material. Female holotype and two female paratypes (nos. 1 and 2) from Bluff, Natal, Africa, 9-3-14, collector unknown, from *Crinoglossa natalensis* Friese.

Type Repositories. Holotype and one paratype (no. 1) in the Snow Entomological Museum at The University of Kansas, remaining paratype in the U. S. National Museum, Washington, D. C.

Petalomium, new subgenus

(Figs. 84-86)

Type, *Parapygmephorus* (*Petalomium*) *krczali*, new species.

This subgenus includes at least a dozen species, most of which are associated with ants. Its members are considered to be highly specialized, as indicated by the characters given below.

Diagnosis. Females separable from those of the remaining subgenera in that the body is broadly oval, the propodosoma likewise broad, in that external ventral I is furcate, in possessing one or two median genital sclerites, because tibiotarsus I usually has a well developed pinnaculum, and in the disproportionate elongation of leg IV, particularly of the tarsus and pretarsus.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 210 to 330μ; width, 145 to 225μ; width between anterior sternocoxal condyles of coxae III, 95 to 145μ; body weakly sclerotized, lacking integumental engravings and usually without coarse punctae.

Gnathosoma. Quadrate or but little longer than wide.

Propodosoma. Dorsum. Broad, distance between internal pseudostigmatal sockets at least slightly, usually much greater than length of dorsum; peritremes with mesal margins emarginate, located in middle third of dorsum; esophageal "finned" structures usually indistinct, single and small to medium in size if distinct. *Venter.* Internal ventrals II slightly to distinctly anterior to external ventrals II; external ventrals I always distinctly forked, bi- or trifurcate; coxa I articulated at oblique angle to longitudinal axis of body; apodemes II arcuate, weak, terminating laterally at areolus of external ventrals I, usually incomplete medially; secondary transverse suture absent; posterior marginal apodemes straight or gently arcuate; distinct, pleated, conjunctival band absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. Setae of fifth segment apical or apicoventral; vulva apical; apical portion of vaginal wall usually sclerotized and distinct, but enlarged, globose to elliptical sclerotization absent; posterior genital sclerite usually triangular and flaplike, rarely indistinct; one or (rarely) two median genital sclerites present, irregular or rounded in shape. *Venter.* External presternals arising on to well anterior of apodemes IV; apodemes III usually indistinct, if distinct, never bending posteriorly at sides; apodemes IV usually extending at least three-quarters of distance to coxal foramina III, rarely less, or indistinct; apodemes IV directed toward or joining coxal foramina III at anterior third or quarter, joining posterior median apodeme on or posterior to line drawn between anterior sternocoxal condyles of coxae III; posterior median apodeme variable, portion behind apodemes IV three-quarters to one and three-quarters times as long as that anterior to apodemes IV; well defined band of opisthosomal conjunctival pleats absent.

Legs. Ratio, length to width of trochanter IV, 1:1.2 to 1:2.3; leg I distinctly to greatly shorter than, always thinner than leg II; tibiotarsus I at least twice as long as wide, subequal to distinctly wider than femurogenu I; pinnacula present or vestigial, if present well developed, twice as long as width at apex; medio-lateral sensory area present or absent, if present, then marginal and irregular in shape, never distinctly circular dorsally; claw I moderate in size,

pedicellate, pedicel variable in size, thumb absent or moderately developed; apical portion of seta *c* of trochanter I not or barely proflexed; basal solenidium of tarsus II arising distinctly from apex of tibia; pretarsi II and III short, usually one-quarter the length of the tarsus or less; pretarsus IV often distinctly elongate but never more than one-third length of tarsus; coxa III elongate-subcordate when viewed in inner ventral aspect, distance between anterior and posterior sternocoxal articulations 25 to 42μ; coxa IV rectangulate, basal third not or only slightly constricted, basal fifth only rarely slightly bulbose, ratio of length to width approximately 1:1.6 to 1:2.3; trochanter IV always distinctly shorter than coxa IV; tarsus IV greatly elongate and thin, usually at least twice length of tarsus III; ratio of femurogenu IV to tarsus IV, 1:5.5 to 1:10.5.

Habits. Nothing is known of the habits of the species included in this genus. One may infer that extreme physogastry does not occur in the females. Seven of the ten forms seen by this author were taken from the bodies of various ants, the other three being found in the soil, in moss, or in woodland litter.

Species thought to belong in *Petalomium:*

?*formicarum* (Berlese, 1904) (*Pygmephorus*)

Specimens Examined. In addition to the types species as follows: nine species from the south-central United States and Panamá, from the following situations or hosts: *Eciton vagans* (Olivier), *E. mexicanum* Roger, *E. dulicius* Forel, (all Formicidae, Dorylinae), *Camponotus* sp. (Formicidae, Formicinae), "ants, not Dorylinae," "under rock, with ants," frass at base of stump.

Parapygmephorus (*Petalomium*) *krczali*,[30] new species

Description of Non-gravid Female. Length, 296μ (288-362, $\bar{X} = 314$); width, 210μ (210-228, $\bar{X} = 221$); width between anterior sternocoxal condyles III, —[31] (162-165); body weakly sclerotized, punctae present but indistinct (to distinct), other integumental markings lacking.

Gnathosoma. Length, —[32] (31-32); width, —[32] (33-34); dorsals stout, sparsely plumose, externals only slightly shorter than internals, arising barely posterior to and well laterad of them; anterior and posterior palpal setae about three μ apart; palpal solenidium II large, capitate, palpal solenidium I tiny, ovoid.

30. This species is named for Dr. Herbert Krczal, Institut für Obstkrankheiten, Heidelberg, Germany, in recognition of his outstanding contributions to the knowledge of this group.

31. This measurement not possible on holotype.

32. This measurement not possible on holotype.

Propodosoma. Dorsum. Broadly inversely T-shaped; distance between internal pseudostigmatal sockets 97μ (97-130, $\bar{X} = 113$); anterior pseudostigmatals sparsely plumose, about 22μ long, arising mesad of pseudostigmatal socket. *Venter.* All setae elongate, stout, distinctly plumose, 54 to 90μ long; internal ventral I much longer than external; lateral and ventral margins of circumgnathosomal foramen not greatly thickened, not forming distinct gnathosomal collar; apodemes II incomplete medially.

Hysterosoma. Dorsum. All dorsal setae sparsely plumose, stout, elongate; dorsals I anterior to line drawn between laterals I by about two areolar diameters, 103μ (85-105, $\bar{X} = 99$) long, 96μ (96-113, $\bar{X} = 106$) apart; laterals I 119μ (108-123, $\bar{X} = 118$) long, much closer to respective dorsal than dorsals to each other; dorsals II 124μ (124-144, $\bar{X} = 138$) apart, 123μ (123-134, $\bar{X} = 128$) long; dorsals III extremely elongate, 161μ (157-189, $\bar{X} = 169$) long, only 59μ (59-66, $\bar{X} = 64$) apart, laterals III 81μ (81-90, $\bar{X} = 86$) long, arising slightly anterior to and well laterad of dorsals; dorsals IV 138μ (138-175, $\bar{X} = 145$) long, about 40 to 50μ apart; laterals IV 59μ (59-74, $\bar{X} = 63$) long, distinctly more slender than dorsals and arising slightly anterior to and well laterad of them; setae of segment V aciculate, sparsely plumose, arising from the ventral margin of the opisthosoma; internal caudal as stout (or stouter) at the base than dorsals III and IV, 64μ (58-70, $\bar{X} = 65$) long, external caudals I and II subequal in size, 19 to 28μ long, distinctly less than half as wide at base as internal caudals, external caudals I arising much closer to internal caudals than to external caudals II; posterior genital sclerite indistinct, median genital sclerite single, rounded (to irregular) in shape. *Venter.* All setae of posterior ventral plate elongate, stout, sparsely plumose, about 55 to 85μ long; line drawn between first axillaries dividing distance between internal and external presternals approximately in half; external presternals laterad of internal presternals, much closer to them than to first axillaries; line drawn between second axillary and internal presternal passing barely anterior to areolus of external presternal; external poststernals arising behind line drawn between posteromesal margins of coxal foramina IV by about a third the length of the coxal base; apodemes III indistinct (to weakly distinct as far as internal presternals); apodemes IV weak but distinct, bending posteriorly at the sides to join mesal margins of coxal foramina III behind their centers.

Legs (all measurements in μ). *Length.* Leg I, 77 (77-81, $\bar{X} = 78$); leg II, 123 (123-147, $\bar{X} = 134$); leg III, 141 (141-162, $\bar{X} = 149$); leg IV, 233 (233-289, $\bar{X} = 261$). *Width.* Leg I, 18 (18-20, $\bar{X} = 19$); leg II, 25 (25-31, $\bar{X} = 28$); leg III, 23 (23-25, $\bar{X} = 24$); leg IV, 18 (18-25, $\bar{X} = 23$). *Segment lengths.* Tr I, —[33] (17-23, $\bar{X} = 20$); tita I, 46 (44-46, $\bar{X} = 45$); tr II, —[33] (36-45, $\bar{X} = 42$); ta II, —[33] (48-58, $\bar{X} = 54$); tr III, —[33] (42-55, $\bar{X} = 48$); ti III, 24 (24-28, $\bar{X} = 26$); ta III, 61 (52-61, $\bar{X} = 57$); cx IV, 59 (59-74, $\bar{X} = 65$); tr IV, 34 (34-44, $\bar{X} = 40$); fege IV, 14 ($\bar{X} = 14$); ta IV, 102 (102-128, $\bar{X} = 115$). *Setation.* Leg I: cx 1T, tr 2T + 1 modified; fege 4T, tita 11T + 9S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 2S, ta 6T; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV: cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Tip of seta *c* of trochanter I not proflexed, seta *d* similar in shape but longer and more slender; solenidium 3 of tibiotarsus I about 14μ, thickly rodlike, attenuate, apex sharply acuminate; solenidium 4 nearly as long as 3, similar in shape but thinner, apex less acuminate; length of pinnaculum distinctly more than twice its width; tibiotarsus I distinctly wider than femurogenu I, elliptical; tibial solenidia of legs II and III basal, clavate, short; solenidium of tarsus II about 11μ, bullet-shaped, apex sharply acuminate; coxa IV rectangulate, ratio of length to width, 1:1.8 to 1:2.1; lateral setae of trochanter IV and tibia IV greatly elongate, the former reaching nearly to, the latter well beyond claw IV; tarsus IV greatly elongate, 102μ (102-128, $\bar{X} = 115$) long, evenly attenuate, the pretarsus also elongate and slender, about 22μ; claws IV greatly reduced, nearly vestigial; ratio of femurogenu IV to tarsus IV, 1:7.3 to 1:9.2.

Habits. Nothing is known of the habits of this species.

Distribution. Known only from the type locality.

Type Material. Female holotype and four female paratypes from Volo, Lake County, Illinois, October 14, 1956, B. Greenberg, from sphagnum moss in tamarack bog (berlese).

Type Repositories. Holotype and one paratype (no. 1) in the Chicago Natural History Museum, Chicago, Illinois, one paratype (no. 2) in the Snow Entomological Museum at The University of Kansas, one paratype (no. 3) in the U. S. National Museum, Washington, D. C., and one paratype in the Zoologisches Institut, Universität Erlangen, Erlangen, Germany.

33. This measurement not possible from holotype.

Acinogaster, new genus

(Figs. 90-92)

Type, *Acinogaster marianae*, new species.

This new genus includes six previously undescribed forms associated with doryline ants in both the Old and New Worlds. Its members are very closely related to and considered by this author to form an "exgroup" of the genus *Parapygmephorus*. They are easily separable from all members of that genus by several interesting specializations as noted below.

Only the non-gravid females are known.

DIAGNOSIS. Females are separable from those of all other genera in the tribe in that at least internal ventrals I and II and axillaries I and II are modified, being enlarged, flattened, and of varying shapes but not setiform.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 170 to 300μ; width, 90 to 175μ; distance between anterior sternocoxal condyles of coxae III, 70 to 120μ; hysterosoma elliptical to ovate; integument of body weakly to moderately sclerotized, lacking engravings; striae absent on most lateral portions of posterior ventral plate; body with or without distinct, coarse punctures.

Gnathosoma. As wide as to slightly wider than long; palpal solenidium 2 large, globular or capitate; esophagus straight, thick, sometimes with short thickened area, "bow-tie" structures lacking.

Propodosoma. Integument weakly sclerotized, similar to that of hysterosoma or with heavily sclerotized areas which are variable in shape and extent. *Dorsum.* Inversely T-shaped, usually thickly so; distance between internal pseudostigmatal sockets distinctly greater than length of propodosoma; lateral margins of circumgnathosomal foramen not greatly thickened to form foraminal collar; posterior margin to posterior third covered by first hysterosomal tergum; pseudostigmata located between posterior half and posterior quarter; peritremes circular, large, weakly rimmed or rim lacking, their mesal margins emarginate or not; peritremes widely separated, located in anterior third of dorsum or in propodosomal shoulders; esophageal "finned" structures indistinct. *Venter.* At least three pairs of setae of anterior ventral plate modified bladelike, paddlelike, or clublike; internal ventrals I anterior to, in line with, or posterior to external ventrals I; internal ventrals II usually in transverse line with, rarely well anterior to external ventrals II, often as close to anterior median apodeme as to latter setae; external ventrals

I not furcate; coxa I articulated obliquely to longitudinal axis of body; apodemes II variable but always weak, appearing as integumental creases or hidden within strongly sclerotized venter, arcuate or sharply U-shaped, complete or not; secondary suture variously developed, also usually appearing creaselike; anterior median apodeme complete, variable in distinctness; posterior marginal apodemes usually straight, often greatly thickened at lateral angles, thickening rarely extending bandlike mesally across venter; pleated conjunctival band distinct between propodosoma and hysterosoma or not.

Hysterosoma. Dorsum. First segment overlapping posterior margin to posterior fourth of propodosoma; fifth segment bearing three pairs of apicoventral setae; vulva apical, distinct, apical portion of vaginal wall usually sclerotized but never thickly so; posterior genital sclerite usually elongate and evenly attenuate posteriorly, flaplike but often indistinctly so, or occasionally broadly triangular and flaplike; median genital sclerite present. *Venter.* Posterior ventral plate with six pairs of setae, its hind margin undulate or broadly emarginate; first axillaries never anterior to anteriormost margin of coxal foramina III by more than twice their areolar diameters; posterior ventral plate distinctly produced over anterior portion of coxae III; external presternals always arising well anterior to apodemes IV, the distance between them much greater than that between internal presternals; external poststernals always arising less than half (usually less than a quarter) the basal width of coxa IV behind mesal, posterior sclerotization of fourth coxal foramen; apodemes III indistinct to distinct, if distinct reaching laterally as far as middle of coxal foramina III but not bending posteriorly to join it; apodemes IV distinct or not, if so then bending posteriorly to join coxal foramina III at or behind middle, joining posterior median apodeme on or between lines drawn between anterior third and posterior third of coxal foramina III; posterior median apodeme distinct or not, variable, if distinct, portion behind apodemes IV usually smaller than that anterior to apodemes IV; well defined band of opisthosomal pleats absent behind coxae IV and dorsally between segments III and IV; opisthosoma distinctly longer than distance between anterior margin of coxa III and posterior margin of coxa IV; opisthosomal venter lacking integumental engravings.

Legs. Moderately elongate, stout, ratio of length to width of trochanter IV, 1:1.4 to 1:2.2; legs I subequal, to slightly or distinctly shorter than legs II, always much longer than gnathosoma; tibio-

tarsus I two to two and one-half times as long as wide, as wide as or only slightly wider than femurogenu I; pinnacula reduced to moderately developed, height sometimes one and one-half times apical width; mediolateral sclerotized area of tibiotarsus I usually well developed, becoming enlarged and circular or nearly so dorsally; claw I dilate basally or not, pedicellate, pedicel usually longer than wide, constricted basally, thumb weakly developed; trochanter I with three setae, the apical portion of seta *c* weakly or strongly proflexed; tarsi II and III each with six tactiles; basal solenidium of tarsus II displaced basad, arising from apical margin of tibia II; basal solenidia of tibiae II and III present; pretarsi II to IV short, never more than one-third the length of the tarsi; claws II and III with large basal dilations, claw IV simple, smaller or rarely absent; pulvilli II and III always distinctly longer than claws, pulvillus IV variable in length; coxa III elongate-subcordate, distance between anterior and posterior sternocoxal articulations, 20 to 30μ; coxa IV rectangulate to short-rectangulate, basal third not or only slightly constricted, basal fifth not or only slightly bulbose, ratio of length to width approximately 1:1.6 to 1:2.0; trochanter IV usually distinctly shorter than, rarely subequal to coxa IV; femurogenu IV usually wider than long, bearing one seta; tarsus IV slender and elongate, evenly attenuate, always at least twice as long as tarsus III; ratio of femurogenu IV to tarsus IV, 1:4.5 to 1:6.8.

HABITS. Little is known of members of the group. The nongravid females are common as phoretics upon many species of army ants, usually between coxae I. According to C. Rettenmeyer (*in litt.*) the number present per ant is small.

To date, six species, all undescribed, are known, these found upon fourteen species of Dorylinae. Table VII summarizes our knowledge of the host relationships of the various American species of the genus.

Although sample sizes are variable, this table presents some useful information as regards host relationships. Only one of the six species of *Acinogaster* is restricted to a single species of ant (sp. V, to *Neivamyrmex legionis*), while each of four species of ants is seen to carry but one mite species as follows: *Eciton hamatum* with only *marianae, E. vagans* with only species XX, and *Neivamyrmex opacithorax* and *nigrescens* with only species XXX.

Species XX is apparently most catholic in its host preference, being known from 11 different species of ants.

Members of the genus offer opportunity to study interrelationships between geographical and host variation.

TABLE VII.—Distribution of *Acinogaster* sp. Upon Various American Doryline Ants

Mite species	Ant species	Number mites/ant species	Percent mite species/ ant species	Percent, total no. all mites/ant species[a]
A. marianae..	*Eciton hamatum* (Fabricus)	53	17	100
	E. burchelli (Westwood)....	255	83	95
			100	
A. sp. III....	*Eciton dulcius* Forel.....	4	4	44
	Nomamyrmex hartigi..... (Westwood)	1	1	25
	N. esenbecki (F. Smith).....	2	2	33
	Labidus praedator (F. Smith)	84	81	60
	L. coecus (Latreille).....	5	5	71
	Neivamyrmex pilosus..... (F. Smith)	5	5	71
	N. gibbatus Borgmeier.....	1	1	33
	N. legionis (F. Smith).....	1	1	14
			100	
A. sp. XX....	*Eciton vagans* (Olivier).....	3	3	100
	E. dulcius.....	5	5	56
	E. mexicanum Roger.....	11	11	100
	E. burchelli.....	14	13	5
	Nomamyrmex hartigi.....	3	3	75
	N. esenbecki.....	4	4	66
	Labidus coecus.....	2	2	
	L. praedator.....	57	54	40
	Neivamyrmex pilosus.....	2	2	29
	N. gibbatus.....	2	2	66
	N. legionis.....	2	2	29
			100	
A. sp. XXX[b]	*Neivamyrmex nigrescens*.... (Cresson)	13	46	100
	N. opacithorax (Emery)....	15	54	100
			100	
A. sp. V.....	*Neivamyrmex legionis*.....	4	100	57

a. Obtained by totalling number of mites for each ant species, apportioning each mite species therefrom.

b. May be only geographic variant of XX.

DISTRIBUTION. Various species are known from Brazil, British Guiana, Trinidad, Panamá, Kansas (U. S. A.), and Angola.

SPECIMENS EXAMINED. In addition to the type species, as follows: *Species II.* ANGOLA: Nova Lisboa Prov., 19 ♀ ♀ from *Dorylus* (*Anomma*) sp. *Species III.* PANAMÁ (C. Z.): Barro Colorado Is., 84 ♀ ♀ from *Labidus praedator.* Same, 5 ♀ ♀ from *L. coecus.*

Same, 4 ♀ ♀ from *Eciton dulcius.* Same, 2 ♀ ♀ from *Nomamyrmex esenbecki.* Same, 1 ♀ from *Neivamyrmex gibbatus.* Same, 5 ♀ ♀ from *N. pilosus.* Cerro Galera (K-6 Road), 1 ♀ from *Nomamyrmex hartigi.* BRAZIL: Nova Teutonia, 27° 11'S., 52°28'W., 1 ♀ from *Neivamyrmex legionis. Species XX.* PANAMA (C.Z.): Barro Colorado Is., 3 ♀ ♀ from *Eciton vagans.* Same, 5 ♀ ♀ from *E. dulcius. Same,* 11 ♀ ♀ from *E. mexicanum.* Same, 4 ♀ ♀ from *Nomamyrmex esenbecki.* Same, 2 ♀ ♀ from *Labidus coecus.* Same, 57 ♀ ♀ from *L. praedator.* Same, 2 ♀ ♀ from *Neivamyrmex pilosus.* Same, 2 ♀ ♀ from *N. gibbatus.* Cerro Galera (K-6 Road), 3 ♀ ♀ from *Nomamyrmex hartigi.* BRAZIL: Nova Teutonia, 2 ♀ ♀ from *Neivamyrmex legionis.* BRITISH GUIANA: Oronoque River at New River, 10 ♀ ♀ from *Eciton burchelli cupiens. Species XXX.* KANSAS: Lawrence, 15 ♀ ♀ from *Neivamyrmex opacithorax.* Univ. Kansas Nat. Hist. Res., 12 ♀ ♀ from *N. nigrescens.* Topeka, 1 ♀ from *N. nigrescens. Species V.* BRAZIL: Nova Teutonia, 27°11′ S., 52°23′ W., 4 ♀ ♀ from *Neivamyrmex legionis.*

Acinogaster marianae,[34] new species

DESCRIPTION OF NON-GRAVID FEMALE. Length, 333μ (267-346, $\bar{X} = 311.40 \pm$ S. E. 8.14); width, 183μ (157-210, $\bar{X} = 181.70 \pm$ S. E. 5.91); width between anterior sternocoxal condyles III, 126μ (101-126, $\bar{X} = 115.44$); body moderately sclerotized.

Gnathosoma. Length, 26μ (24-30, $\bar{X} = 26.50$); width, 25μ (25-31, $\bar{X} = 28.50 \pm$ S. E. 0.65); dorsals stout, internals slightly longer than externals, arising well mesad and slightly in front of them; distance between externals greater than that between external and respective lateral; palpal tooth large, distinct; solenidium II large, globular or capitate, solenidium I strobiloid, arising nearly laterad of II.

Propodosoma. Dorsum. Broadly inversely T-shaped (shape varying somewhat according to mount), distance between internal pseudostigmatal sockets, 91μ (72-91, $\bar{X} = 84.33$); sclerotization distinctive, uneven, heaviest in circular area immediately mesad of each pseudostigma, this area forming a broad tubercle; posterior margin of dorsum excavated, thickly sclerotized, sclerotized areas becoming broader at the sides; anterior pseudostigmatal setae short, nude, bristlelike, posterior pseudostigmatals stout, sparsely plumose, arising well laterad of and only slightly posterior to internal

34. This species is named in honor of Mrs. Marian E. Rettenmeyer who, with her husband Carl, collected the type series.

pseudostigmatal socket. *Venter.* External and internal ventrals I and internal ventrals II modified, greatly thickened and flattened; internal sternals I and II clavate, similar in shape, but I distinctly larger than II; external ventral I broader than internal but elongate-cylindrical, its apex acuminate; external ventral II stoutly setiform, plumose; internal ventral I slightly behind line drawn between external ventrals I (but relationships depend greatly upon mount); internal ventrals II approximately in transverse line with external ventrals II; posterior marginal apodemes well developed, becoming greatly enlarged at the sides; anterior median apodeme prolonged taillike behind union with posterior marginal apodemes; band of pleated conjunctiva distinct (or indistinct) dorsally between propodosoma and hysterosoma.

Hysterosoma. Dorsum. All dorsal setae stout, setiform, elongate, moderately plumose; dorsals I 56μ (51-64, $\bar{X} = 60.89$) long, 63μ (53-69, $\bar{X} = 61.90 \pm$ S. E. 1.84) apart, distinctly closer to respective laterals than to each other; laterals I arising only slightly behind line drawn between dorsals, 99μ (78-108, $\bar{X} = 92.78$) long; dorsals II 56μ (46-56, $\bar{X} = 52.70 \pm$ S. E. 1.25) long, 81μ (59-85, $\bar{X} = 76.50 \pm$ S. E. 2.71) apart; dorsals III 68μ (59-76, $\bar{X} = 67.22$) long, 74μ (59-84, $\bar{X} = 72.80 \pm$ S. E. 2.44) apart; laterals III well laterad of and slightly behind dorsals III, 44μ (31-50, $\bar{X} = 43.44$) long; dorsals IV 88μ (70-92, $\bar{X} = 83.20 \pm$ S. E. 2.35) long, 62μ (45-76, $\bar{X} = 61.30 \pm$ S. E. 3.30) apart; laterals IV posterolateral to dorsals IV, 50μ (40-51, $\bar{X} = 46.30 \pm$ S. E. 1.34) long; internal caudals much longer and stouter than other setae of segment V, 44μ (36-45, $\bar{X} = 40.90 \pm$ S. E. 0.96) long; areoli of external caudals I nearly contiguous with those of internal caudals, 17μ (15-18, $\bar{X} = 16.57$) long; external caudals II slightly longer than external caudals I and of the same conformation, 20μ (17-23, $\bar{X} = 19.00 \pm$ S. E. 0.64), about three to four times as far from external caudals I as the latter are from internal caudals; median genital sclerite distinct, globular (to irregular) in shape. *Venter.* First and second axillary setae modified, remaining setae of posterior ventral plate setiform, moderately and subequally sized, nude or nearly so, flagellate; first axillary bladelike, straight, with distinct prickle, second axillary similar but moderately proflexed near tip; external presternals well in front of apodemes IV, only slightly behind first axillaries, in lateral one quarter of posterior ventral plate; internal poststernals slightly laterad of internal presternals, approximately on transverse line drawn across posterior termination of posterior median apodeme;

poststernals not reaching halfway to posteriormost margin of opisthosoma; mesal portion of hind margin of posterior ventral plate broadly and shallowly lobate, lateral margins indistinct.

Legs (all measurements in μ). *Length.* Leg I, 97 (84-100, $\bar{X} = 94.80 \pm$ S. E. 1.67); leg II, 121 (100-126, $\bar{X} = 117.10 \pm$ S. E. 2.75); leg III, 128 (109-140, $\bar{X} = 126.67$); leg IV, 208 (173-214, $\bar{X} = 200.70 \pm$ S. E. 4.38). *Width.* Leg I, 14 (14-20, $\bar{X} = 17.60 \pm 0.65$); leg II, 25 (23-30, $\bar{X} = 26.90 \pm$ S. E. 0.82); leg III, 22 (20-25, $\bar{X} = 23.10 \pm$ S. E. 0.53); leg IV, 18 (15-19, $\bar{X} = 17.30 \pm$ S. E. 0.42). *Segment lengths.* Tr I, 26 (25-30, $\bar{X} = 26.33$); tita I, 54 (46-54, $\bar{X} = 51.50 \pm$ S. E. 0.85); tr II, 41 (30-41, $\bar{X} = 37.00 \pm$ S. E. 1.21); ta II, 44 (39-48, $\bar{X} = 44.20 \pm$ S. E. 1.03); tr III, 47 (37-51, $\bar{X} = 45.89$); ti III, 23 (20-23, $\bar{X} = 21.80 \pm 0.33$); ta III, 47 (40-52, $\bar{X} = 45.40 \pm 1.16$); cx IV, 56 (44-57, $\bar{X} = 53.70 \pm$ S. E. 1.46); tr IV, 34 (31-37, $\bar{X} = 34.50 \pm$ S. E. 0.69); fege IV, 13 (11-13, $\bar{X} = 12.30 \pm$ S. E. 0.21); ta IV, 81 (66-85, $\bar{X} = 78.10 \pm$ S. E. 1.98); *width of coxa IV,* 26 (23-30, $\bar{X} = 27.00$). *Setation.* Leg I: cx 1T, tr 3T, fege 4T, tita 11T + 8S; leg II: cx 1T, tr 3T, fege 3T, ti 4T + 2S, ta 6T; leg III: cx 1T, tr 2T, fege 2T, ti 4T + 1S, ta 6T; leg IV; cx 1T, tr 2T, fege 1T, ti 4T + 1S, ta 6T.

Apex of seta *c* of trochanter I distinctly proflexed, seta *d* sinuate, resembling sense seta; mediolateral sclerotized plate of tita I prominent between solenidia 2 and 3, marginal, rounded; solenidium 3 of tibiotarsus I short, strobiloid, distad of above spot, solenidia 1 and 2 arising together beneath it, one clavate-pedicellate, the other bullet-shaped; claw I moderately sized, arising from funnel-shaped pedicel; solenidium of tibia II basal, strobiloid, solenidium of tarsus II displaced basad, arising from apical margin of tibia II, bullet-shaped, with apical prickle; solenidium of tibia III distinctly smaller than that of tibia II, clavate; coxa IV rectangulate, ratio of length to width, 1:1.5 (1:1.4 to 1:1.6); external apical seta of tibia IV longest seta of leg; tarsus IV very elongate, slender, tapering basally; ratio of femurogenu IV to tarsus IV, 1:3.4 (1:3.4 to 1:4.7).

HABITS. See description of genus.

DISTRIBUTION. Known only from Panamá and from Trinidad, British West Indies.

TYPE MATERIAL. Female holotype from Barro Colorado Island, Panamá (Canal Zone), June 16, 1956, C. W. and M. E. Rettenmeyer, from *Eciton hamatum,* colony E-189 (Slide No. 1804). Two

paratypes (nos. 3 and 4) same data except taken August 17, 1956, from *E. burchelli,* colony No. E-253. Two paratypes (nos. 6 and 8) same data as preceding except taken on May 12, 1956, from colony No. E-148. Paratype No. 8 same data except taken April 20, 1956, from colony No. E-149. Two paratypes (nos. 1 and 5) same data except taken March 1, 1955, C. W. Rettenmeyer from colony 55-B-II. Two paratypes (nos. 2 and 7) from 7 mi. N. W. of Balboa, Cocolí, Panamá (C. Z.), January 1, 1957, W. Lundy, from *E. burchelli.*

Type Repositories. Holotype and four paratypes (nos. 3, 4, 8, 9) in the Snow Entomological Museum at The University of Kansas. One paratype (no. 2) in the Zoologische Institut, Universität Erlangen, Erlangen, Germany. One paratype (no. 1) in the U. S. National Museum, Washington, D. C. One paratype in the British Museum (Natural History), London. One paratype (no. 6) in the private collection of C. W. Rettenmeyer, Kansas State University. One paratype (no. 5) in the private collection of the author.

Specimens Examined. Other than the type series, as follows: Panamá (C. Z.): Barro Colorado Island, various dates between Feb. 9, 1955, and Aug. 17, 1956, C. W. and M. E. Rettenmeyer or C. W. Rettenmeyer, 247 ♀ ♀ on *Eciton burchelli.* Same locality and collectors, various dates between March 21 and July 9, 1956, 53 ♀ ♀ from *E. hamatum.* Seven mi. N. W. of Balboa, Cocolí, Jan. 1, 1957, W. Lundy, 6 ♀ ♀ from *E. burchelli.* Trinidad: Arima Valley, Spring Hill Estate, April 6, 1935, N. A. Weber, 1 ♀ from *E. burchelli.* South margin, Nariva Swamp, March 10, 1935, N. A. Weber, 1 ♀ from *E. b. urichi* Forel. Northern Range, just north of St. Augustine, June 2, 1935, N. Weber, 1 ♀ from *E. b. urichi.* British Guiana: Oronoque River at New River, July 21, 1936, N. A. Weber, 3 ♀ ♀ from *E. b. cupiens* Santschi.

Pseudopygmephorus, new genus

(Figs. 93-94)

Type, *Pygmephorus tarsalis* Hirst, 1921.

This genus is erected to contain a number of forms closely related to and perhaps directly ancestral to the genera *Microdispus* and *Neopygmephorus.* Primitive forms of the genus, *e. g. P. sellnicki* (Krczal, 1958) superficially resemble members of *Siteroptes* (*Siteroptoides*), but closer examination indicates that they are probably not direct descendents of the latter, but are more closely related to *Pygmephorus* and certain *Parapygmephorus,* and the development

of such characteristics as elongate legs I and sicklelike claws on legs I to III may be regarded as secondary. Members of the genus show increasing specialization, forms considered by the author to be the most advanced closely resembling less specialized forms of the genus *Neopygmephorus*. Because the members of the two groups may be satisfactorily separated, and because of the size of the genus *Neopygmephorus*, the author prefers to consider *Pseudopygmephorus* a distinct genus containing at least fifteen described forms.

DIAGNOSIS. In addition to the key characters given above, females may be distinguished from those of other neopygmephorines by the following combination of characters: external presternals arising from or barely in front of apodemes IV or, if not, then apodemes III distinct laterally and bending posteriorly to meet anterior sternocoxal condyles III; claw I rarely lacking, otherwise moderate to small in size, without thumb, always arising from a distinct, stalklike pedicel.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 160 to 300μ; width 85 to 160μ; width between anterior sternocoxal condyles of coxae III, 50 to 100μ; hysterosoma rather narrowly to broadly elliptical in dorsoventral aspect, posterior margin evenly rounded to truncate; body weakly to moderately sclerotized, without scalelike or "pebbled" integumental markings, not striate on most lateral portions of posterior ventral plate but usually distinctly punctate.

Gnathosoma. Always distinctly longer than wide; palps semipalmate, possessing one or more apical teeth, comprising about half length of gnathosoma; chelicerae small, usually indistinct; small circumesophageal pump sometimes present, a second, "bow-tie-shaped" circumesophageal structure often present behind pump.

Propodosoma. Dorsum. Elongate, inversely T-shaped or trapezoidal, length usually much greater than, rarely subequal to distance between internal pseudostigmatal sockets; anterior portion prolonged hoodlike anteriorly and ventrally over gnathosoma, circumgnathosomal foramen ventral; posterior margin narrowly covered by first hysterosomal segment; pseudostigmata located in posterior one third; two distinct pairs of propodosomal setae; peritremes dorsal or dorsolateral, elongate and throughlike, long-guttate, or guttate, if as first two then diverging anteriorly, if as the latter then stigmatal openings in median or posteromedian excavation; esophageal "finned" structure distinct or not, if distinct, then posterior globose structure always more prominent than

elongate anterior one, fins indistinct in both. *Venter.* Internal ventrals I distinctly anterior to externals, internal ventrals II slightly to well anterior to external ventrals II, usually much closer to them than to anterior median apodeme, both pairs rarely approximate to coxal foramina II; external ventrals I commonly bifurcate; coxa I articulated at nearly a right angle to longitudinal axis of body or distinctly obliquely; apodemes II arcuate, together sometimes lyrate, or weakly W-shaped, always complete; secondary transverse apodeme usually absent, rarely present laterally; anterior median apodeme strong and complete; posterior marginal apodemes strong, straight to gently arcuate; distinctly pleated conjunctival band absent between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First segment covering only posterior quarter to posterior third of propodosoma; fifth segment bearing two (rarely) or three pairs of ventral to apicoventral setae; vulva apical and distinct, often located within genital sulcus; vaginal walls usually distinct apically, globose or elliptical pumplike enlargements usually lacking (present in *sellnicki* group); posterior genital sclerite irregularly rounded, triangular, or rarely, triangular and flaplike. *Venter.* Posterior ventral plate with five or six pairs of setae, if five then second axillaries missing; hind margin of posterior ventral plate variable, entire and linear or lobate or (rarely, *sellnicki* group) tripartite, incisions reaching nearly to posterior foraminal margin of coxa IV; external presternals always arising from or barely before apodemes IV, or if well anterior to apodemes IV, then directly behind internal presternals; transverse distance between external presternal and internal presternal as great as or greater than longitudinal distance between external presternal and first axillary; external poststernal behind posterior foraminal thickening by less, usually much less, than basal width of coxa IV; apodemes III variable in definition and extent; apodemes IV directed toward anterior third or quarter of, reaching coxal foramina III or not, if so, then bending sharply posteriorly to join foramina behind their centers (*sellnicki* group); if apodemes IV reach foraminal margin, then apodemes III are well defined and bend sharply posteriorly to meet anterior sternocoxal condyles; posterior median apodeme well defined, portion behind apodemes IV not more than one and one-half times that anterior to apodemes IV; bands of opisthosomal conjunctival pleats absent; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV; opisthosomal venter lacking integumental engravings.

Legs. Leg I usually longer than or subequal to, always wider than leg II; tibiotarsus I elongate, at least twice as long as wide, only rarely distinctly wider than femurogenu I; pinnacula lacking; mediolateral sensory area present or not, if present marginal and irregular in shape; claw I simple or basally dilated, small to moderate in size, distinctly pedicellate, pedicel always much longer than wide, stalklike, thumb lacking or greatly reduced; trochanter I with three setae, seta *c* with apical portion proflexed; tarsi II and III each with six tactiles; solenidia of tibiae II and III present; pretarsi II to IV short, one-quarter the length of the tarsi or less; claws II to III simple or dilated basally, claws IV simple, subequal to or smaller than those of II and III; coxa III subcordate or triangular as viewed in ventral aspect; coxa IV short-rectangulate to rectangulate, basal third with or without distinct constriction, basal fifth distinctly bulbose or not, ratio of length to width, 1:1.3 to 1:2.2; trochanter IV at least slightly shorter than coxa IV; tarsus IV short to moderately long, usually abruptly narrowed, always distinctly longer than tarsus III; ratio of femurogenu IV to tarsus IV, 1:2.8 to 1:3.7.

Species thought to belong to *Pseudopygmephorus:*

abdominalis (Berlese, 1904) (*Pygmephorus*)
abdominalis polonicus (Willmann, 1949) (*Pygmephorus*)
abdominalis var. *sudetica* (Willmann, 1956) (*Pygmephorus*)
arcticus (Sig Thor, 1934) (*Pediculoides*)
arvorum (Krczal, 1959) (*Pygmephorus*)
decumanus (Krczal, 1959) (*Pygmephorus*)
disparisetae (Jacot, 1936) (*Pygmephorus*)
haarloevi (Krczal, 1958) (*Pygmephorus*)
inconspicuus (Berlese, 1904) (*Pygmephorus*)
kochi (Krczal, 1959) (*Pygmephorus*)
?*quadratus* (Ewing, 1917) (*Pygmephorus*) = (*sellnicki* Krczal?)
sellnicki (Krczal, 1958) (*Pygmephorus*)
suecicus (Krczal, 1959) (*Pygmephorus*)
tarsalis (Hirst, 1921) (*Pygmephorus*)
togatus (Willmann, 1942) (*Pygmephorus*)
willmanni (Krczal, 1959) (*Pygmephorus*)

HABITS. Unknown. None have been found to be phoretic upon insects, although two species, *haarloevi* and *willmanni* are known only from the nests of the ant, *Lasius flavus* Mayr. Species known only from decaying plant materials are *kochi, decumanus,* and *abdominalis* var. *sudetica.* Other forms have been taken from soil and from small mammals.

While some forms such as *haarloevi* and *willmanni* may be restricted in their host associations, the ecological distribution of some species is amazingly broad. *P. sellnicki,* for example, is recorded by Krczal, (1959b), from various small rodents and insectivores, from soil, and from lily bulbs. The present author finds a form considered to be the same species in various other habitats (see "Specimens examined").

Mites associated with rodents are often found in the nests or in food caches, and, as Vitzthum (1943), has stated, probably stand only in a phoretic relationship to them.

Specimens Examined. Five species, including *sellnicki* and probably *tarsalis,* from most of the United States and from England and Japan, from the following situations or hosts: commercial mushroom houses, peach orchard soil, grass, grain, leaf mold, moss, decayed tomatoes, pea ensilage, frostscar, oat straw, lily bulbs, African marigolds, manure, decaying log, treehole of *Fagus grandifolia,* unoccupied nest of *Microtus* sp., from *Peromyscus maniculatus gracilis* (LeConte), burrow of *Cynomys* sp. and debris pile of *Neotoma* sp. (all Cricetidae), from *Pipistrellus subflavus* (F. Cuvier) (Chiroptera).

Neopygmephorus, new genus

Type, *Pygmephorus blumentritti* Krczal, 1959.

The author erects this genus to include a large number of forms placed by previous authors in the genus *Pygmephorus.* As presently conceived, the genus remains one of the largest in the family, containing at least thirty species, these divided into the two subgenera *Allopygmephorus* and *Neopygmephorus sensu stricto.* The former contains but two forms which differ greatly from *Neopygmephorus s. str.,* and secondarily resemble some Microdispini in having lost one pair of propodosomal and one pair of caudal setae and because the most lateral margins of the posterior ventral plate possess distinct pleats. Because intergradation between these more specialized forms and typical species of *Neopygmephorus* seems to occur, they are considered as subgenera herein.

Species of *Neopygmephorus* are most closely related to those of *Parapygmephorus* and *Pseudopygmephorus.*

Except for the male of one species, to be described elsewhere, only the non-gravid females are known. Species are known from Europe, Asia, North and South America, Australia, and Antarctica.

DIAGNOSIS. Females of *Neopygmephorus* are separable from those of all other genera in the tribe by the following combination of characters: leg I usually more slender than, rarely as wide as leg II; coxa IV usually broadly constricted near basal third, coxal base appearing bulbose or bilobate, or, if not, then legs long and slender, ratio of length to width of trochanter III 1:2.3 to 1:4.2.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 145 to 390μ; width, 70 to 230μ; distance between anterior sternocoxal condyles III, 70 to 155μ; hysterosoma rather narrowly to broadly ellipitical or oval; body moderately to heavily sclerotized, only rarely with integumental engravings, these restricted to the lateral or posterolateral portions of the posterior ventral plate if present; striae rarely present on most lateral portions of above plate; body usually distinctly punctate.

Gnathosoma. Well developed, usually only slightly longer than wide, never wider than long; chelicerae tiny, if distinct, needlelike.

Propodosoma. Dorsum. Inversely T-shaped to broadly trapezoidal, shape greatly dependent upon mount; lateral margins of circumgnathosomal foramen not thickened or enlarged to form collar; dorsum narrowly to nearly completely covered by first hysterosomal segment; pseudostigmata usually located in posterior third; one (rarely) or two pairs of propodosomal setae; peritremes usually rimmed, circular or transversely ovoid, their mesal margins nearly always broken or emarginate; peritremes usually smaller than, rarely subequal to diameter of external pseudostigmatal socket; peritremes located in mesal or posterior (rarely) third of propodosoma; esophageal "finned" structures distinct or not, if distinct then usually three in number. *Venter.* Internal ventrals I usually posterior to or in a transverse line with external ventrals I, rarely anterior to them; internal ventrals II distinctly anterior to externals II and much closer to them than to anterior median apodeme; external ventrals I forked or not; coxa I always articulated distinctly obliquely to longitudinal axis of body; apodemes II usually appearing arcuate and complete (see morphology p. 46), terminating anteriorly at external sternal I or incomplete laterally; secondary transverse apodeme usually present and distinct as far as apodemes II (see morphology, p. 46), or more rarely distinct only laterally or absent entirely; anterior median apodeme complete or not; posterior marginal apodemes moderately developed medially, straight or gently arcuate; distance between apodemes I

and II distinctly less than that between apodemes II and posterior marginal apodemes; pleated conjunctival band not visible between propodosoma and hysterosoma.

Hysterosoma. Dorsum. First tergum usually covering only posterior quarter, rarely posterior three-quarters of propodosomal dorsum; fifth segment bearing two or (usually) three pairs of setae, these apical or apicoventral; vulva apical, distinct, vagina sometimes sclerotized apically but lacking globose or elliptical pump-like organ; posterior genital sclerite usually distinct, narrowly to broadly triangular and flaplike or (rarely) formed otherwise or absent; median genital sclerite lacking. *Venter.* Posterior ventral plate with six pairs of setae, its hind margin entire, straight to broadly rounded; external presternals usually arising at least one areolar width anterior to apodemes IV, rarely less; external poststernals usually arising at least half the basal width of coxa IV behind posteromesal sclerotization of fourth coxal foramen; apodemes III distinct or not, never bending at sides to fuse with anterior sternocoxal condyles III; apodemes IV (except in *Allopygmephorus*) extending at least three-quarters of distance to coxal foramina III; apodemes IV usually directed toward or joining coxal foramina at or in front of line drawn between their centers; apodemes IV joining posterior median apodeme on or above line drawn between points demarking anterior third of foraminal margin; posterior median apodeme well defined, portion behind apodemes IV usually at least one and two-thirds times as long as that anterior to apodemes IV; thick bands of opisthosomal conjunctival pleats absent, thin bands occasionally present, especially dorsally between segments three and four; opisthosoma distinctly longer than distance between anterior margin of coxal foramen III and posterior margin of coxal foramen IV.

Legs. Legs usually elongate and thin, ratio of length to width of trochanter IV, 1:2.4 to 1:4.5, only rarely under 1:2.7; leg I usually shorter and thinner than, rarely subequal to leg II; tibiotarsus I usually elongate, usually at least twice as long as wide, distinctly wider than femurogenu I or not; pinnacula lacking or if present reduced, free portion not much higher than width at apex; mediolateral sclerotized area present or not, if present varying in shape and location; claw I usually present, dilate basally, small to moderate in size, distinctly pedicellate, pedicel usually much longer than wide, occasionally constricted basally and as wide or wider

than long; thumb lacking or greatly reduced; apical portion of seta *c* of trochanter I strongly or weakly proflexed and attenuate; tarsi II and III each with six tactiles; solenidia of tibiae II and III present, solenidium of tarsus II arising from the latter's base; claws II and III basally dilate, claws IV subequal to them in size or smaller, simple; coxa III short, subcordate in inner ventral aspect, distance between anterior and posterior sternocoxal articulations, 16 to 33μ (usually 16-25); coxa IV rectangulate, basal third always slightly, usually greatly constricted, basal fifth distinctly to greatly bulbose, ratio of length to width, 1:2.0 to 1:3.1; trochanter IV variable in length, distinctly shorter to much longer than coxa IV; tarsus IV short, variously shaped, usually much longer than, rarely subequal to tarsus III; ratio of femurogenu IV to tarsus IV, 1:2.0 to 1:6.2.

Key to the Subgenera of *Neopygmephorus* (Females)

1(*a*). With one pair of dorsal propodosomals; two pairs of setae on posterior segment; first hysterosomal tergum covering at least posterior three-fifths of propodosoma (depending upon mount); tarsus IV short, ratio of femurogenu IV to tarsus IV about 1:2.0
Allopygmephorus, new subgenus, p. 228

1(*b*). With two pairs of dorsal propodosomals; two (rarely) or three pairs of setae on posterior segment; first hysterosomal tergum covering at most posterior half of propodosoma; tarsus IV longer, ratio of femurogenu IV to tarsus IV rarely less than 1:2.5
Neopygmephorus, sensu stricto, p. 230

Allopygmephorus, new subgenus

(Figs. 95-96)

Type, *Pygmephorus matthesi* Krczal, 1959.

This subgenus includes *N.* (*A.*) *matthesi* and at least one closely related, undescribed form[35] in the author's collection. All are phoretic upon various Hydrophilidae (Coleoptera). These mites resemble some Microdispini in lacking one pair of propodosomal dorsals and in the loss of a pair of setae from segment V, in often possessing enlarged poststernals, and because the most lateral portions of the posterior ventral plate are striate. They differ from the Microdispini and resemble *Neopygmephorus* in the conformation of the legs, the presence of a modified seta on trochanter I, the arrangement of the setae of the posterior ventral plate, the shape of the propodosomal dorsum, and in the position and shape of the

35. The author has two forms which he considers to be separate species. Both follow Krczal's description and illustrations of *matthesi* closely yet exhibit strong setational and minor structural differences.

peritremes. Two species placed herein in the subgenus *Neopygmephorus* likewise lack a pair of setae on segment V and possess short tarsi IV. They are possibly intermediates between the two subgenera.

DIAGNOSIS. In above key.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 140 to 220μ; width not ascertainable; distance between anterior sternocoxal condyles of coxae III 70 to 90μ; posterior ventral plate without integumental engravings but striate on most lateral portions.

Propodosoma. Dorsum. Only anterior pseudostigmatal setae present, these arising between peritremes and pseudostigmata; dorsum nearly to completely covered by first hysterosomal tergum. *Venter.* Internal ventrals I anterior to or in transverse line with external ventrals I [36]; external ventrals I not furcate; secondary transverse suture absent.

Hysterosoma. Dorsum. Fifth segment with only two pairs of apicoventral setae. *Venter.* External presternals not more than one areolar diameter behind line drawn between internal presternal and corresponding first axillary; external poststernal arising less than half the basal width of coxa IV behind posteromedial sclerotization of fourth coxal foramen; apodemes IV indistinct or extending only about halfway to mesal margins of coxal foramina III; distance along posterior median apodeme between junctions of apodemes III and IV short, less than 13μ.

Legs. Short and stout; tibiotarsus I less than twice as long as wide; mediolateral, dorsal sclerotized area circular, distinct; claws IV well developed, simple and more slender but nearly as long as claws III; ratio of length to width of trochanter III about 1:1.8 to 1:2.0; ratio of length to width of coxa IV about 1:2.0 to 1:2.2; ratio of length to width of trochanter IV about 1:2.4 to 1:3.0; tarsus IV short and stout, ratio, length femurogenu IV to tarsus IV, 1:2.0 to 1:2.4; trochanter IV distinctly shorter than coxa IV.

HABITS. Nothing is known of the habits of these mites. They are capable, presumably, of spending considerable periods of time under water. The specimens of *Paracymus* (below) were captured while submerged.

36. Krczal's drawing of *matthesi* shows internal sternals I to be posterior to the externals. The propodosoma of this specimen is tipped, however, and it is probable that these setae are in a transverse line.

SPECIMENS EXAMINED. *Species No. 1.* MISSOURI: Weldon Springs, 1 ♀ from *Tropisternus blatchleyi* D'Orchymont. *Species No. 2.* KANSAS: Muscotah, 2 ♀ ♀ from beneath pronotum of *Paracymus* sp.[37]

Subgenus *Neopygmephorus sensu stricto*

(Figs. 97-100)

Type, *Pygmephorus blumentritti* Krczal, 1959.

The present author places in this subgenus the forms considered by most American workers to be "typical" members of the genus *Pygmephorus*. The group is large. Krczal (1959b), includes about fifteen species considered herein to belong to *Neopygmephorus s. str.* Approximately 12 additional species, all undescribed, are in the possession of the present author.

DIAGNOSIS. See key above.

DESCRIPTION OF NON-GRAVID FEMALE. Length, 212 to 385μ; width, 115 to 220μ; distance between anterior sternocoxal condyles III, 70 to 150μ.

Propodosoma. Dorsum. Posterior margin to posterior half covered by first hysterosomal tergum; two pars of propodosomal setae; peritremes located in mesal third of propodosoma.

Hysterosoma. Venter. Apodemes IV joining coxal foramina III at anterior third or quarter, if not, then joining posterior median apodeme on or above line drawn between anteriormost margins of coxal foramina III; external poststernals usually behind posteromesal sclerotization of coxa IV by at least half the basal width of the coxa; distance along posterior median apodeme between junctions of apodemes III and IV usually longer than 13μ.

Legs. Tibiotarsus I elongate, always at least twice as long as wide; ratio, length to width of trochanter III, 1:2.4 to 1:4.1; ratio, length to width of coxa IV, 1:2.0 to 1:3.1; ratio, length to width of trochanter IV, 1:2.5 to 1:4.5; tarsus IV moderately elongate to elongate, 25 to 100μ long, ratio of femurogenu IV to tarsus IV 1:2.8 to 1:6.2.

Species thought to belong to *Neopygmephorus s. str.*

amplus (Krczal, 1959) (*Pygmephorus*)
arboris (Krczal, 1959) (*Pygmephorus*)
bavaricus (Krczal, 1959) (*Pygmephorus*)
blumentritti (Krczal, 1959) (*Pygmephorus*)
comatus (Krczal, 1959) (*Pygmephorus*)

37. Det. F. N. Young, Indiana University.

cultratus (Berlese, 1904) (*Pygmephorus*)
cultratus var. *minor* (Berlese, 1904) (*Pygmephorus*)
delanyi (Evans, 1950) (*Pygmephorus*)
ellipticus (Krczal, 1959) (*Pygmephorus*)
formosus (Jacot, 1936) (*Pygmephorus*)
gracilis (Krczal, 1958) (*Pygmephorus*)
lithobii (Krczal, 1958) (*Pygmephorus*)
matthesi (Krczal, 1959) (*Pygmephorus*)
montanus (Willmann, 1956) (*Pygmephorus*)
pannonicus (Willmann, 1951) (*Pygmephorus*)
pratensis (Krczal, 1959) (*Pygmephorus*)
scutacaroides (Vitzthum, 1925) (*Microdispodides*)
tumidosetosus (Willmann, 1951) (*Pygmephorus*)

HABITS. Nothing is known of the habits of the species in this group. Their macrohabitats are similar to those of *Pseudopygmephorus.* Two species, *lithobii* and *amplus,* are known respectively from *Lithobius* (Chilopoda) and from the nest of a "wild bee." Other species are found in soil or litter in assocation with decaying plant material or in the nests of small rodents, insectivores, and birds.

SPECIMENS EXAMINED. Fourteen species, including *blumentritti,* from various parts of the United States including Alaska and from West Australia, from the following situations or hosts: humus in mixed white pine and hemlock forest, litter from fallen *Tilia americana* L., leaf litter in alder swamp, melly leaf litter and moss (Australia), abandoned nest of field mouse, occupied nest of *Peromyscus* sp. (Cricetidae), from "mouse nest," from nest of *Microtus* sp. (Cricetidae), from nest of *Pitymys pinetorum scalopsoides* (Aububon and Bachman) (Cricetidae), debris from nest of *Neotoma* sp. (Cricetidae), debris in nest of *Colaptes cafer* (Gmelin) (Piciformes), from hooded warbler (Parulidae), from *Microtus ochrogaster* (Wagner) (Cricetidae), from tundra, from soil, moss, "*Brachystachium* sp.," under bark of apple, punky stump, from tideline detritus.

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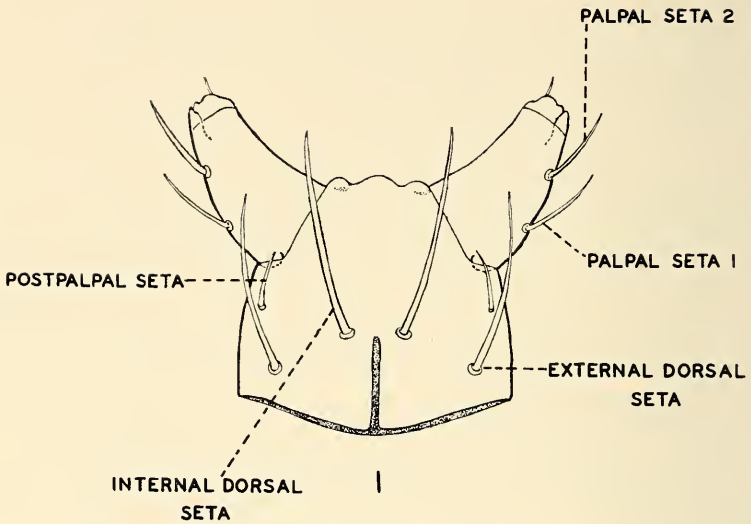

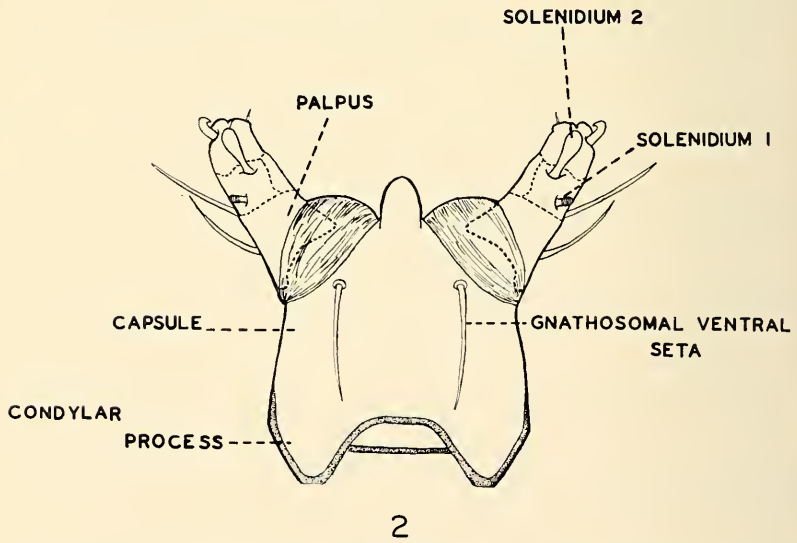

FIGS. 1-2. Gnathosoma of female *Neopygmephorus* sp., dorsal (fig. 1) and ventral (fig. 2) aspects. Labelled structures agree with the terminology used in the text.

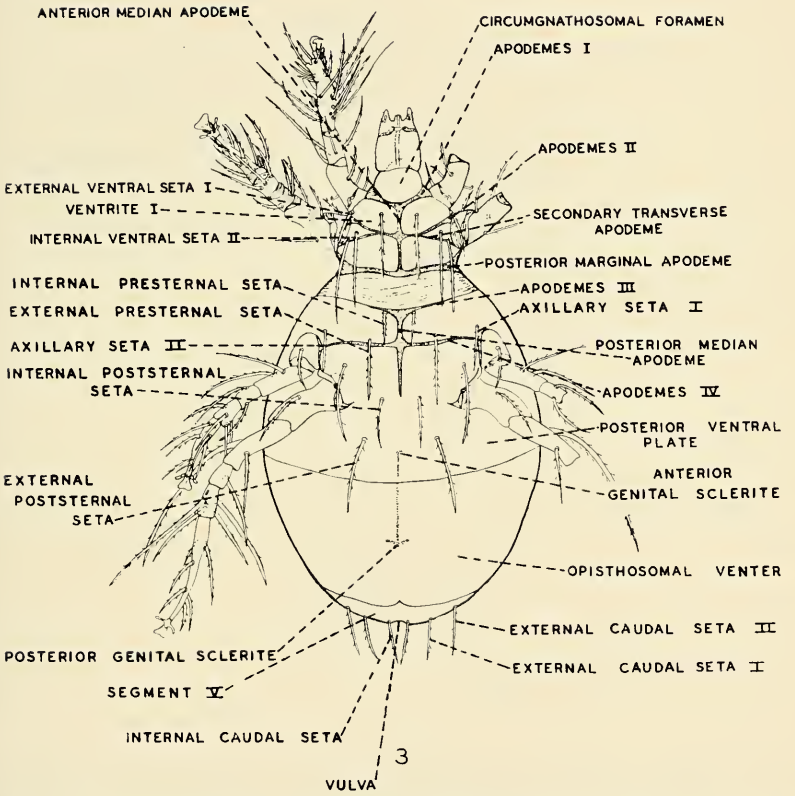

FIG. 3. *Neopygmephorus* sp., female, ventral aspect. Labelled structures agree with the terminology used in the text.

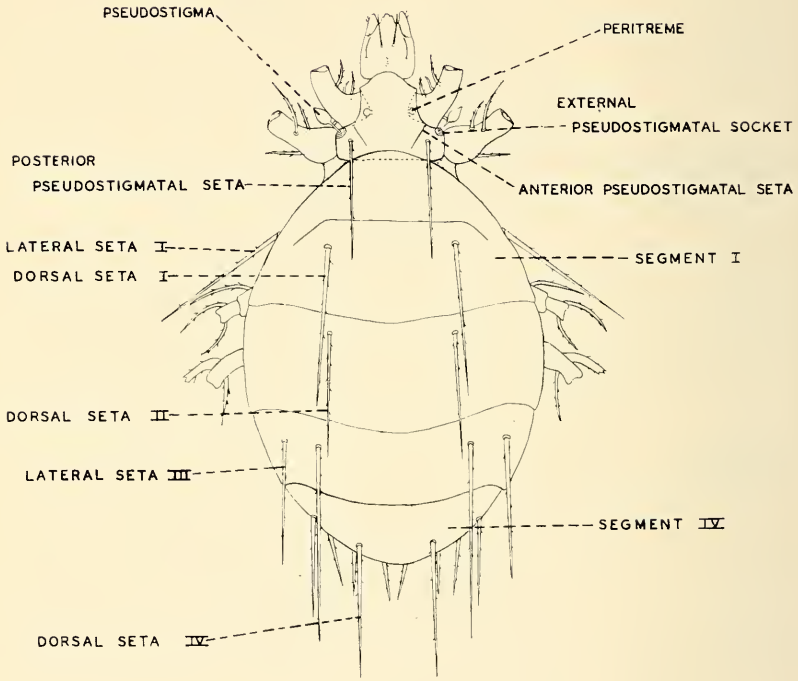

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FIG. 4. *Neopygmephorus* sp., female, dorsal aspect. Labelled structures agree with the terminology used in the text.

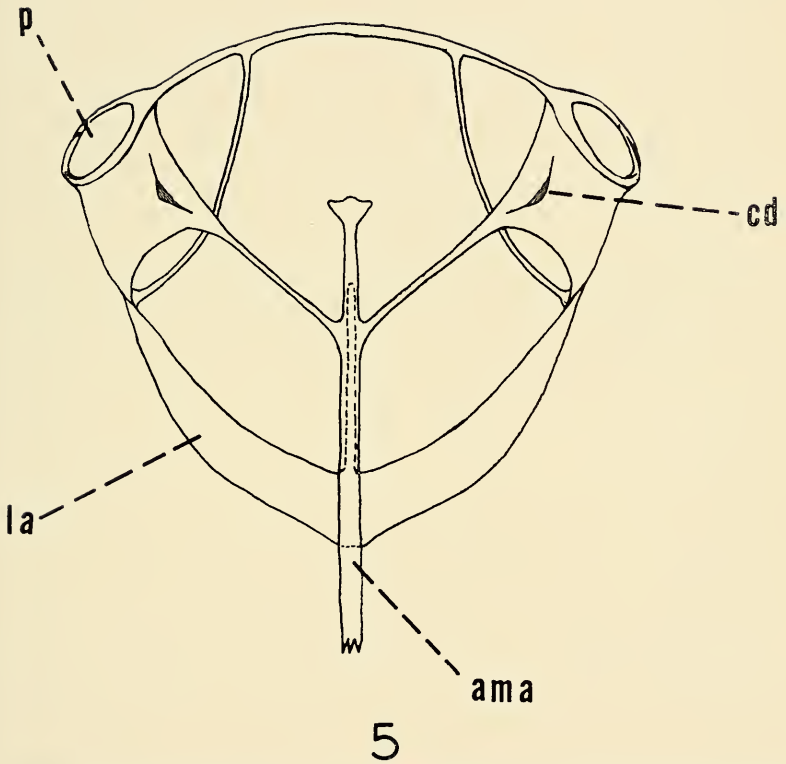


FIG. 5. Propodosomal arcula of *Adactylidium beeri*. Holotype female, ventral aspect. ama = anterior median apodeme; la = lateral apodeme; cd = anterior condyle of coxa I; p = peritreme.

FIG. 6. Diagram of relationships within the superfamily Tarsonemoidea.

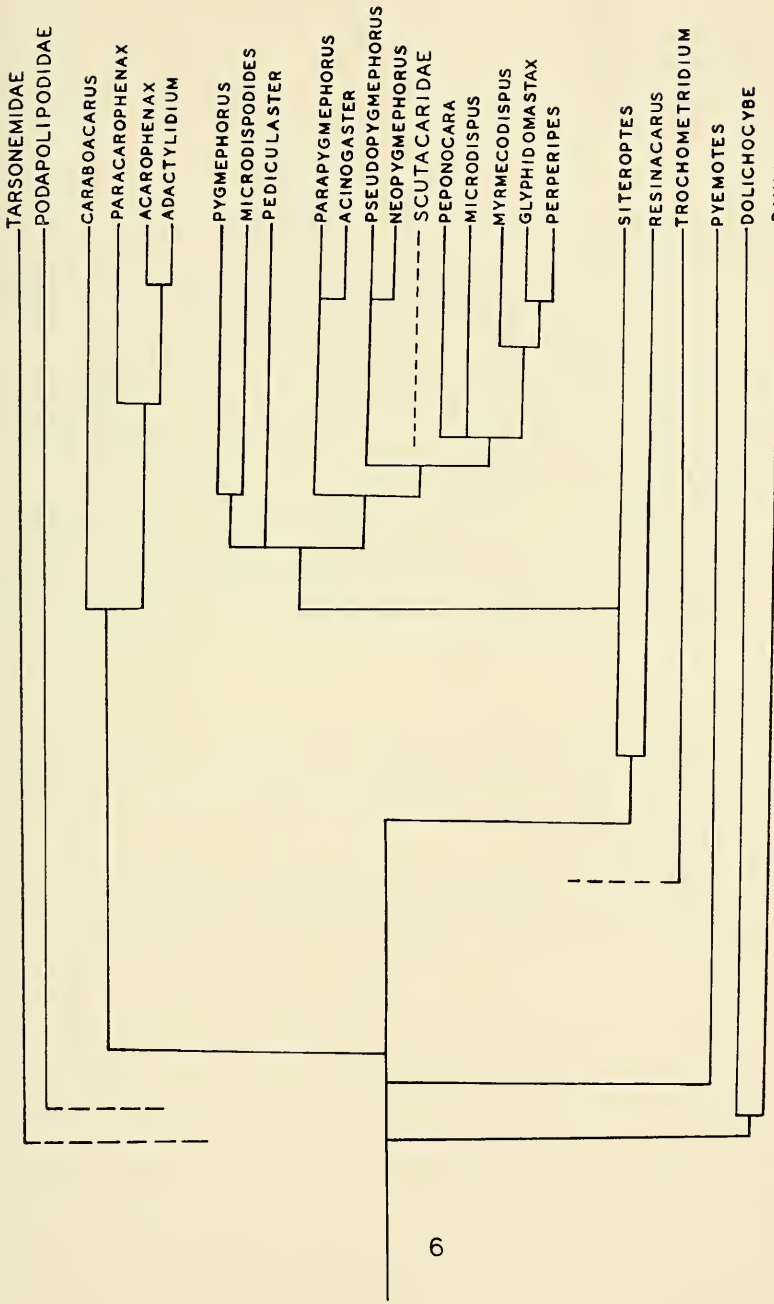

TARSONEMIDAE
PODAPOLIPODIDAE
CARABOACARUS
PARACAROPHENAX
ACAROPHENAX
ADACTYLIDIUM
PYGMEPHORUS
MICRODISPODIDES
PEDICULASTER
PARAPYGMEPHORUS
ACINOGASTER
PSEUDOPYGMEPHORUS
NEOPYGMEPHORUS
SCUTACARIDAE
PEPONOCARA
MICRODISPUS
MYRMECODISPUS
GLYPHIDOMASTAX
PERPERIPES
SITEROPTES
RESINACARUS
TROCHOMETRIDIUM
PYEMOTES
DOLICHOCYBE
PAVANIA
6

FIG. 7. A proposed evolution of the apodemes, setation, and coxae of the posterior ventral plate.

A. Apodemes III and IV oblique, incomplete medially, terminating laterally at anterior sternocoxal condyles III and IV, respectively. Coxae III and IV triangular, similar in shape. (*Pavania, Dolichocybe, Pymotes,* many Acarophenacinae).

B. Apodemes IV complete medially, at least trace of posterior median apodeme present. (*Metasiteroptes macer.*)

C. Similar to (B) but coxa IV differing strongly from coxa III in shape and proximity. (*Siteroptes s. str.*)

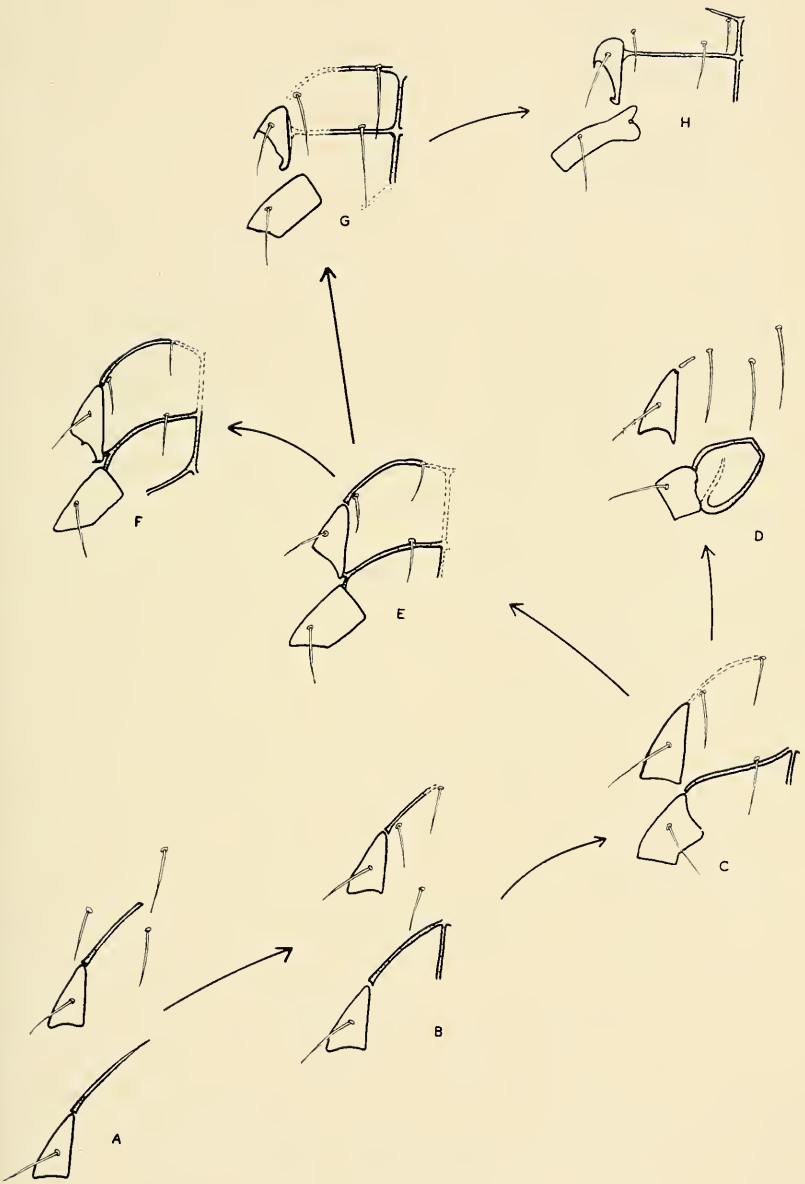
D. Modification of (C) as found in *Trochometridium tribulatum.*

E. Apodemes III and IV usually well developed, complete and joined by posterior median apodeme. Apodeme IV appearing furcate distally, its anterior branch meeting the posterior ventral margin of coxal foramen III, its posterior branch terminating along the anterior dorsal margin of coxal foramen IV. (*Siteroptes s. str., Siteroptoides, Pediculaster.*)

F. As (E) but with apodeme V well developed. (*Siteroptoides, Pediculaster.*)

G. Loss of posterior branch of apodeme IV, anterior migration of superior branch to center of coxal foramen III or beyond. Apodemes III and IV often not complete laterally. Apodemes V may be present. (*Pygmephorus,* most *Microdispini, Parapygmephorus, Pseudopygmephorus.*)

H. Apodemes III incomplete laterally, apodemes IV usually complete and joining the mesal margin of coxal foramen III along its anterior half. Coxa IV elongate and with basal constriction. (*Neopygmephorus.*)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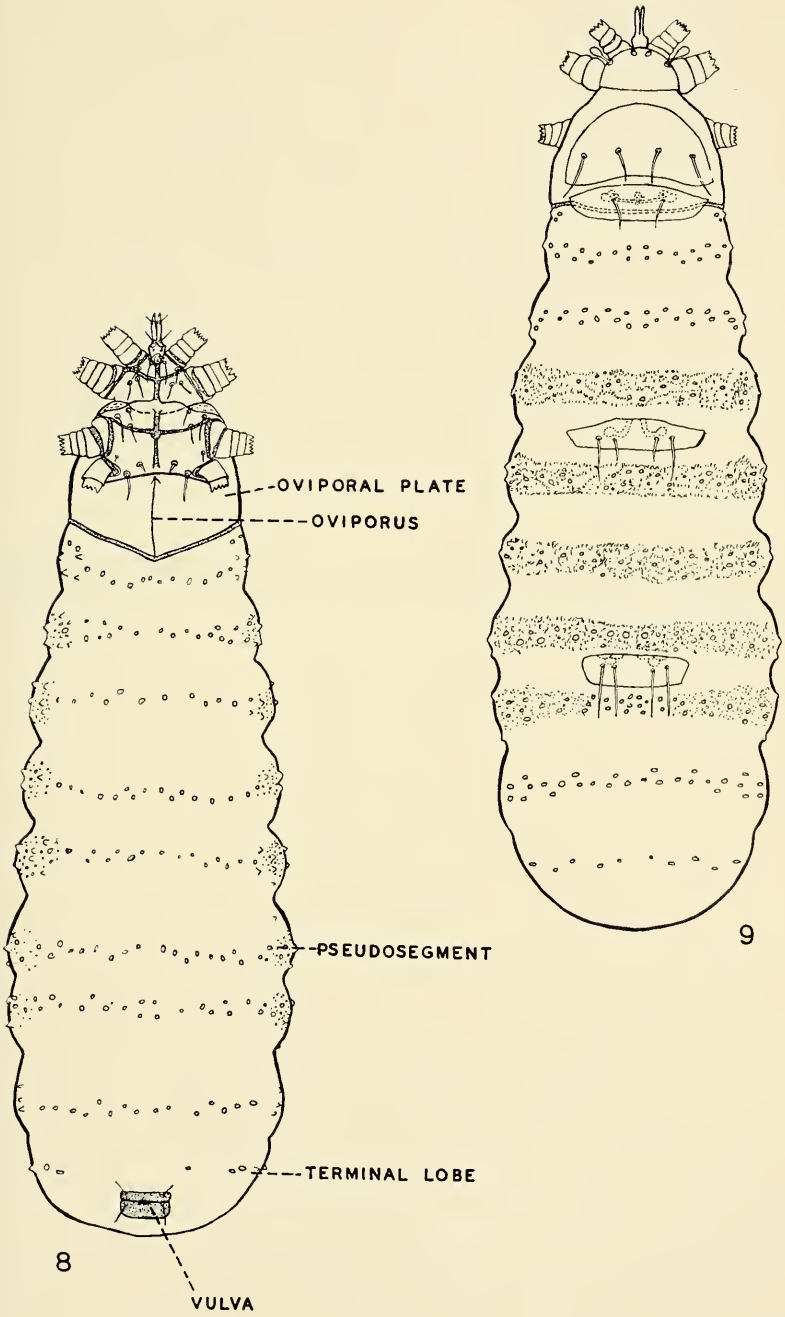
FIGS. 8-9. *Perperipes ornithocephalá*, gravid female.


OVIPORAL PLATE
OVIPORUS
PSEUDOSEGMENT
TERMINAL LOBE
VULVA
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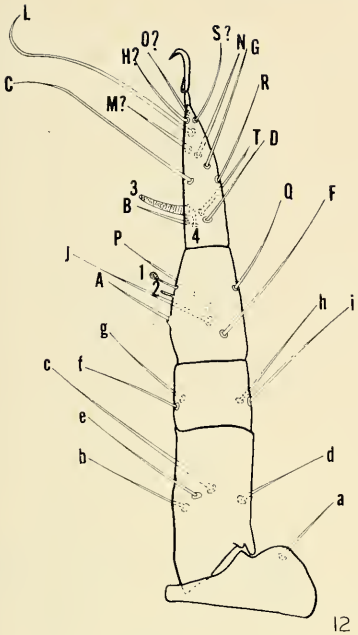
FIGS. 10-12. Legs of *Siteroptes* sp. (nr. *antiquissimus*), ventral aspect, setal nomenclature after Krczal (1959b). Fig. 10, leg I, female. Fig. 11, leg IV, female. Fig. 12, leg I, male.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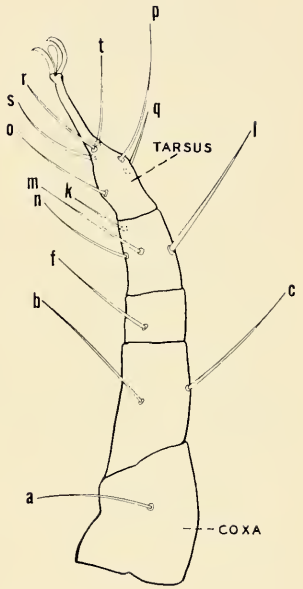
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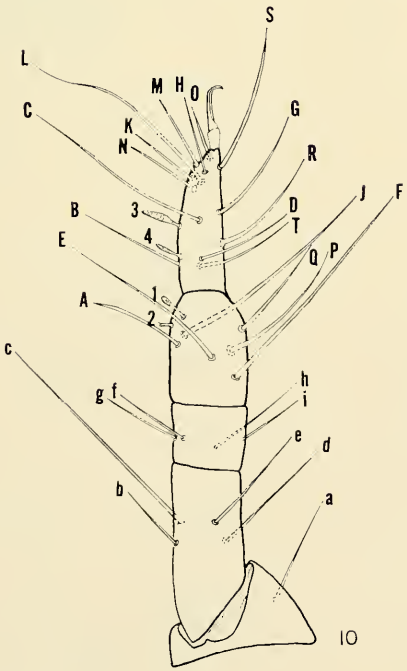
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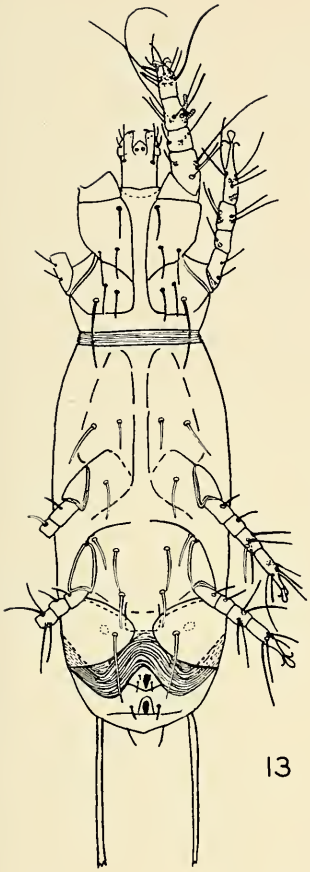
10

Figs. 13-16. *Dolichocybe keiferi*, syntypes. Figs. 13-14, female. Figs. 15-16, male.



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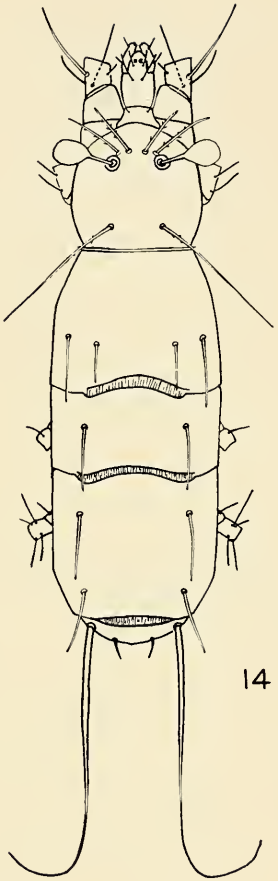

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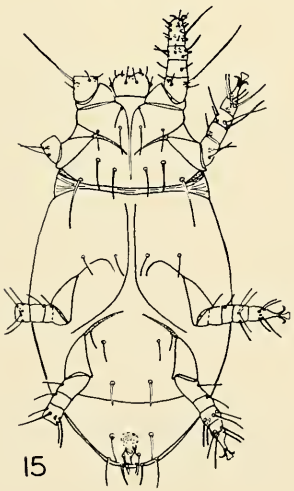

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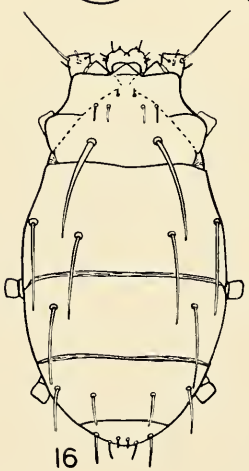

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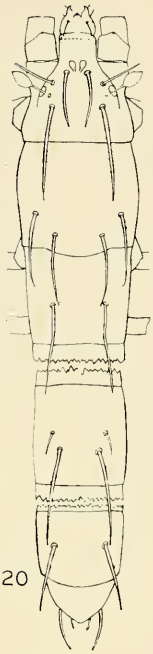
FIGS. 17-18. *Pavania fusiformis*, female syntype.

FIGS. 19-20. *Siteroptes* (*Metasiteroptes*) *macer*, female. Composite, holotype and paratype.



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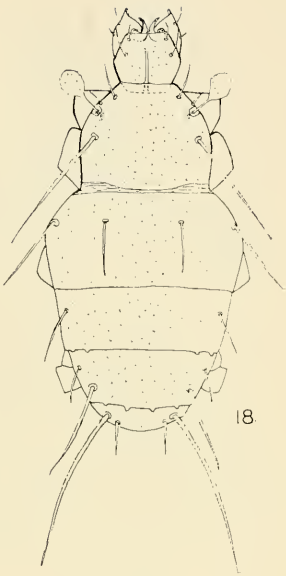

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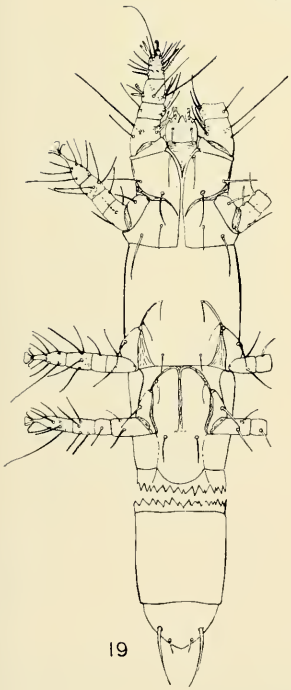

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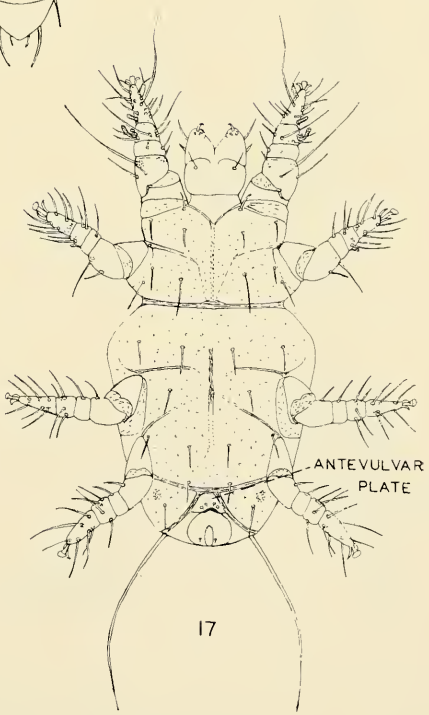

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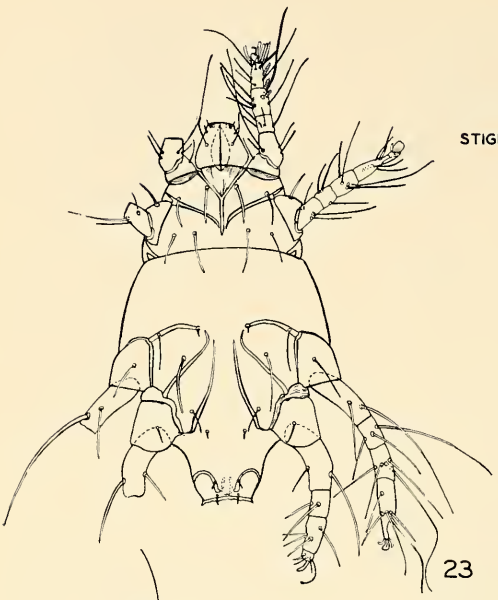
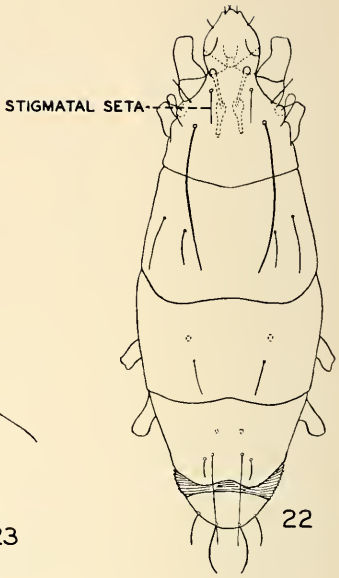
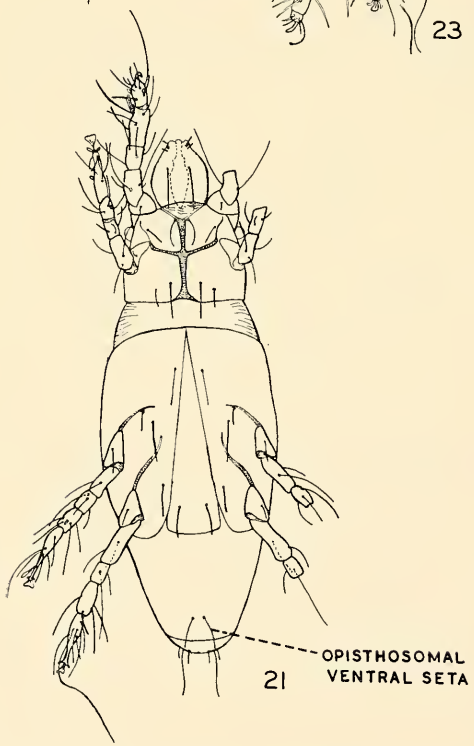
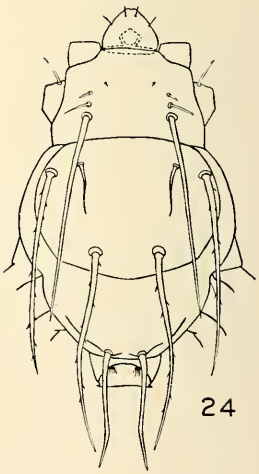
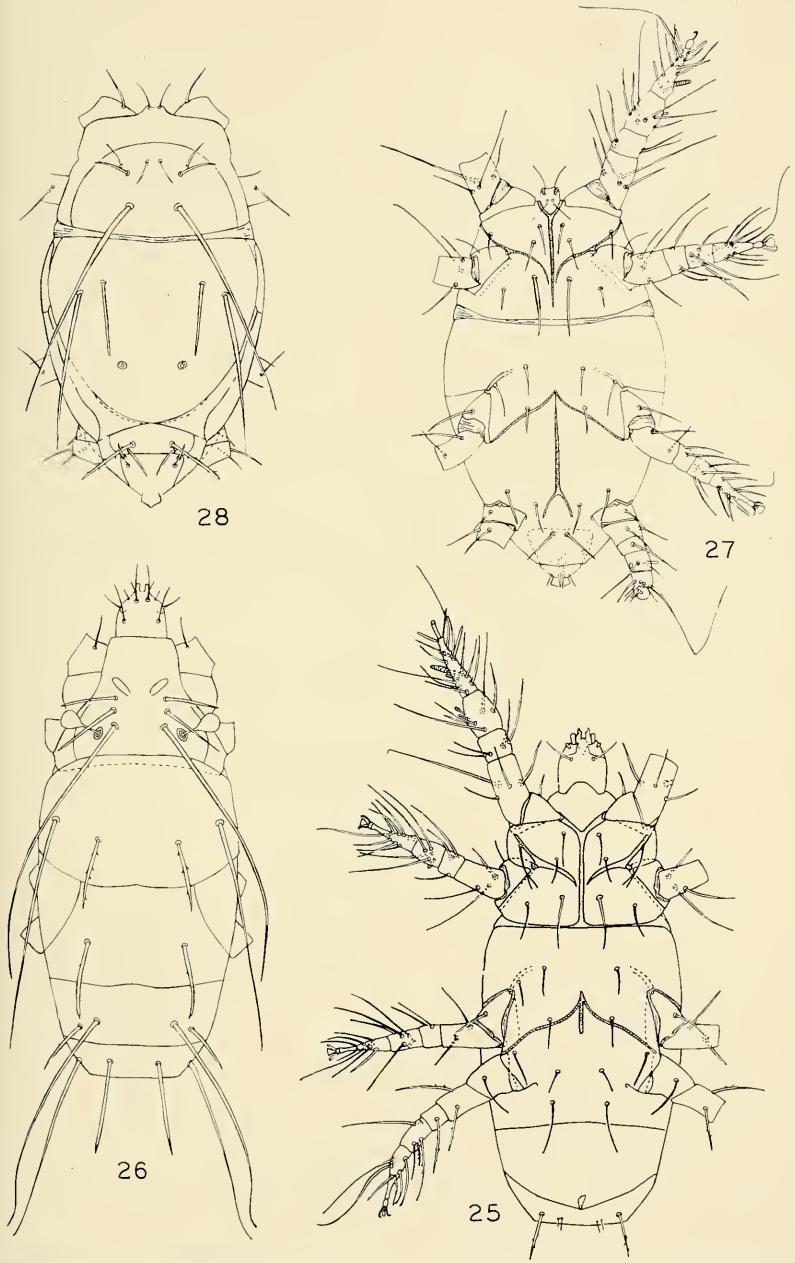






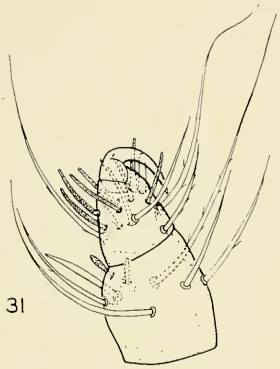


FIGS. 21-24. *Pyemotes* sp. (*near ventricosus*). Arlington, Va., *ex* wasp nest. Figs. 21-22, female. Figs. 23-24, male.



FIGS. 25-28. *Siteroptes* (*Siteroptes*) sp. (nr. *antiquissimus*). Figs. 25-26, female. Figs. 27-28, male.

FIGS. 29-34. *Trochometridium tribulatum*, holotype female. Figs. 31-34, right tibiae and tarsi of legs I, II, IV, III, respectively, ventral aspect.



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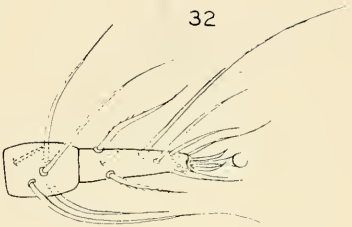

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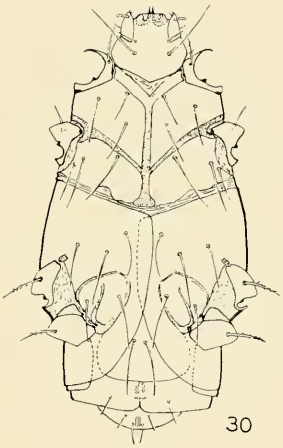

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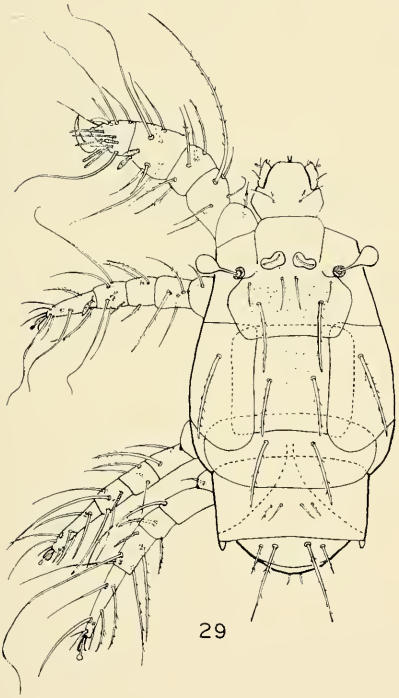

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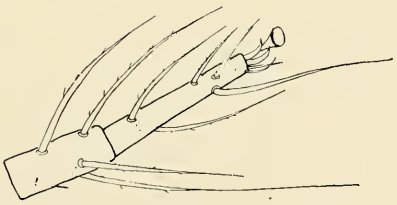

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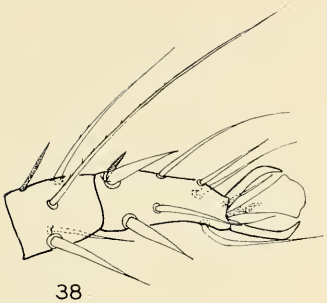
FIGS. 35-40. *Trochometridium tribulatum*, allotype male. Figs. 37-40, right tibiae and tarsi of legs I-IV, respectively, ventral aspect.



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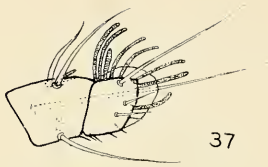

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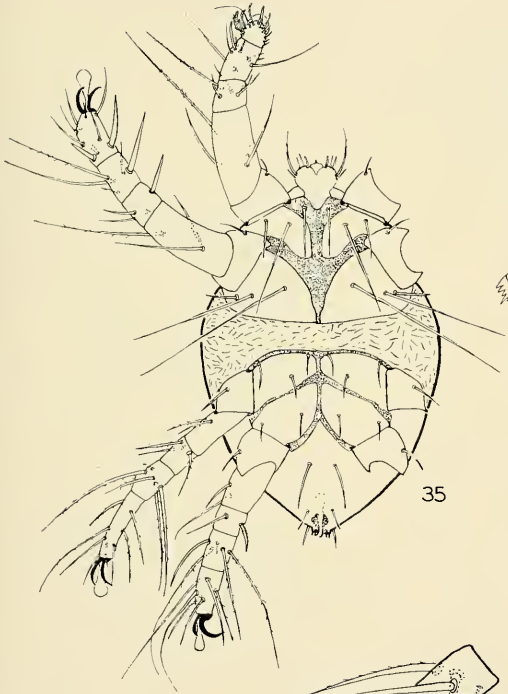

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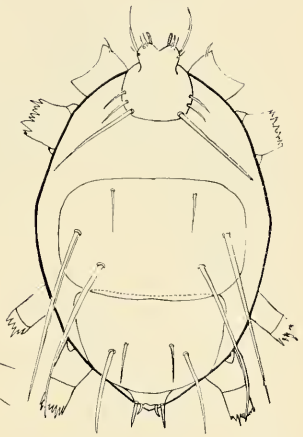

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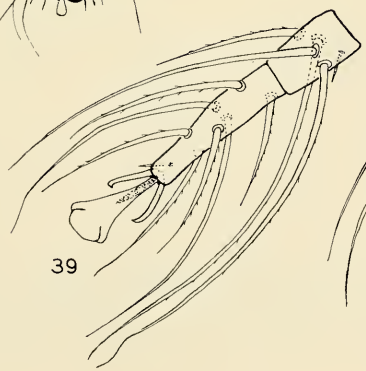

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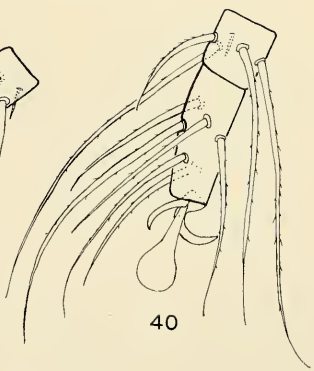

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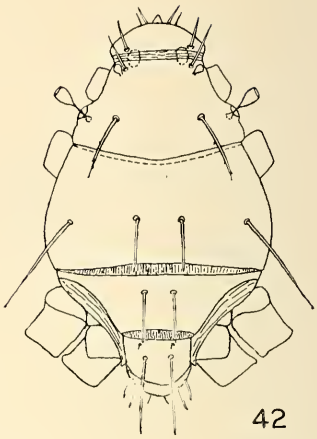

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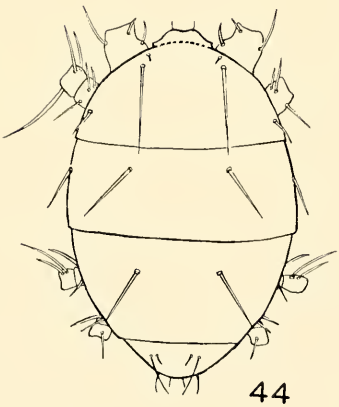

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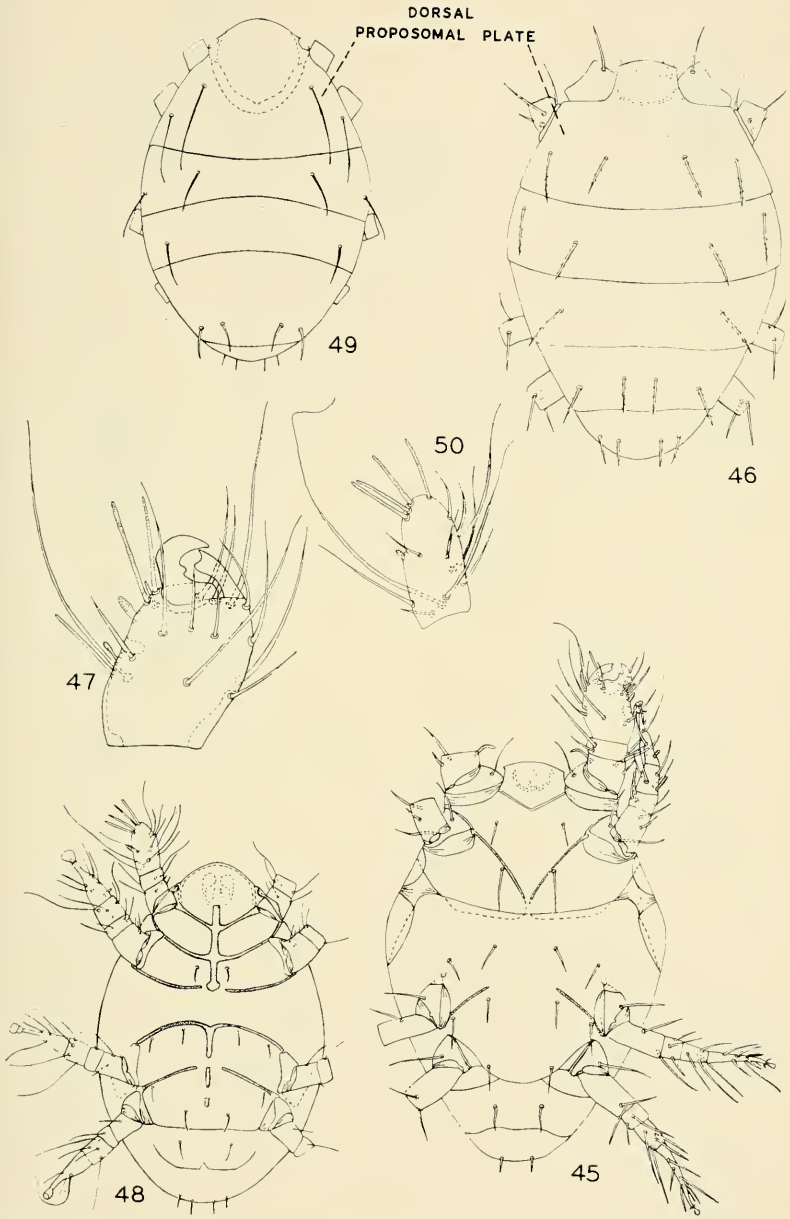
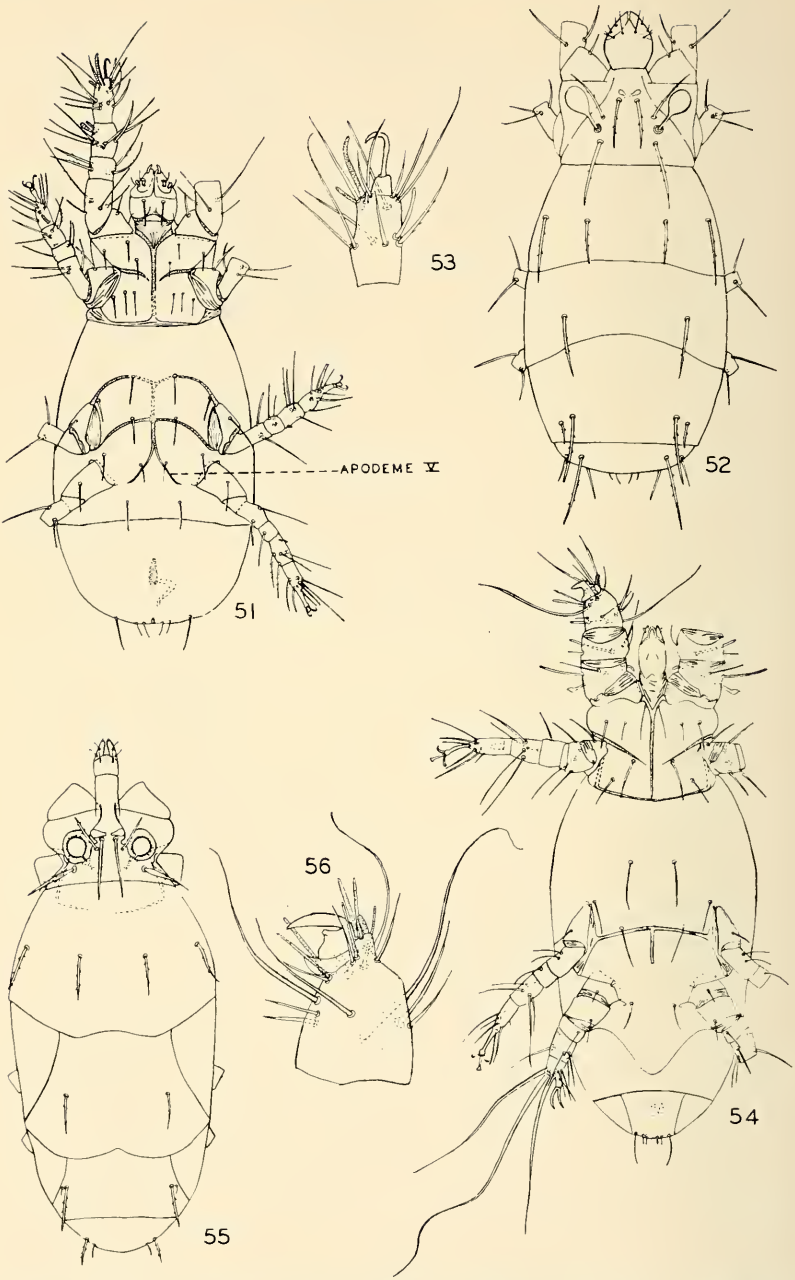
FIGS. 41-42. *Caraboacarus* sp. female, Lawrence, Kansas, from *Agonoderus* sp.

FIGS. 43-44. *Acarophenax tribolii,* female. India, jute bagging (taken at Puerto Rico in quarantine).



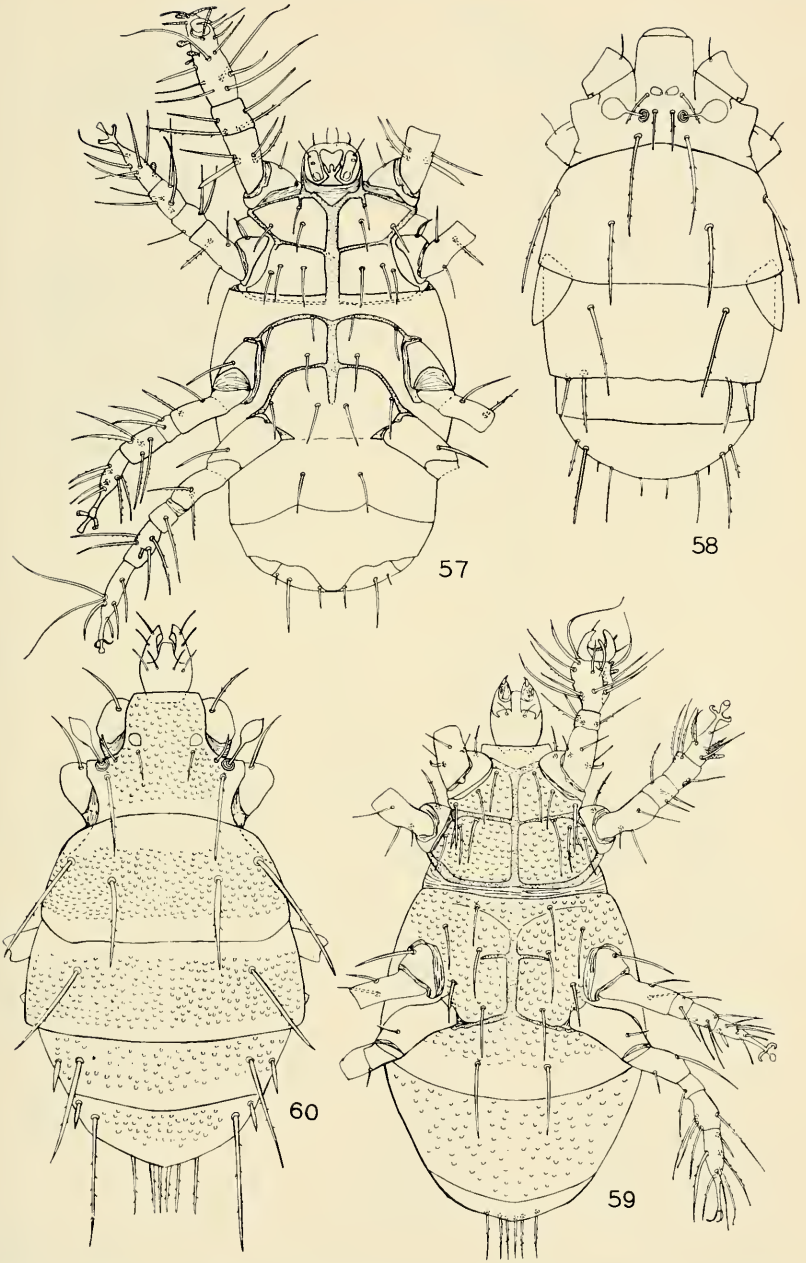
FIGS. 45-47. *Paracarophenax dybasi*, female. Composite, holotype and paratypes 1-3. Fig. 47, left tibiotarsus I, ventral aspect.

FIGS. 48-50. *Adactylidium beeri*, holotype female. Fig. 50, right tibiotarsus I, ventral aspect.



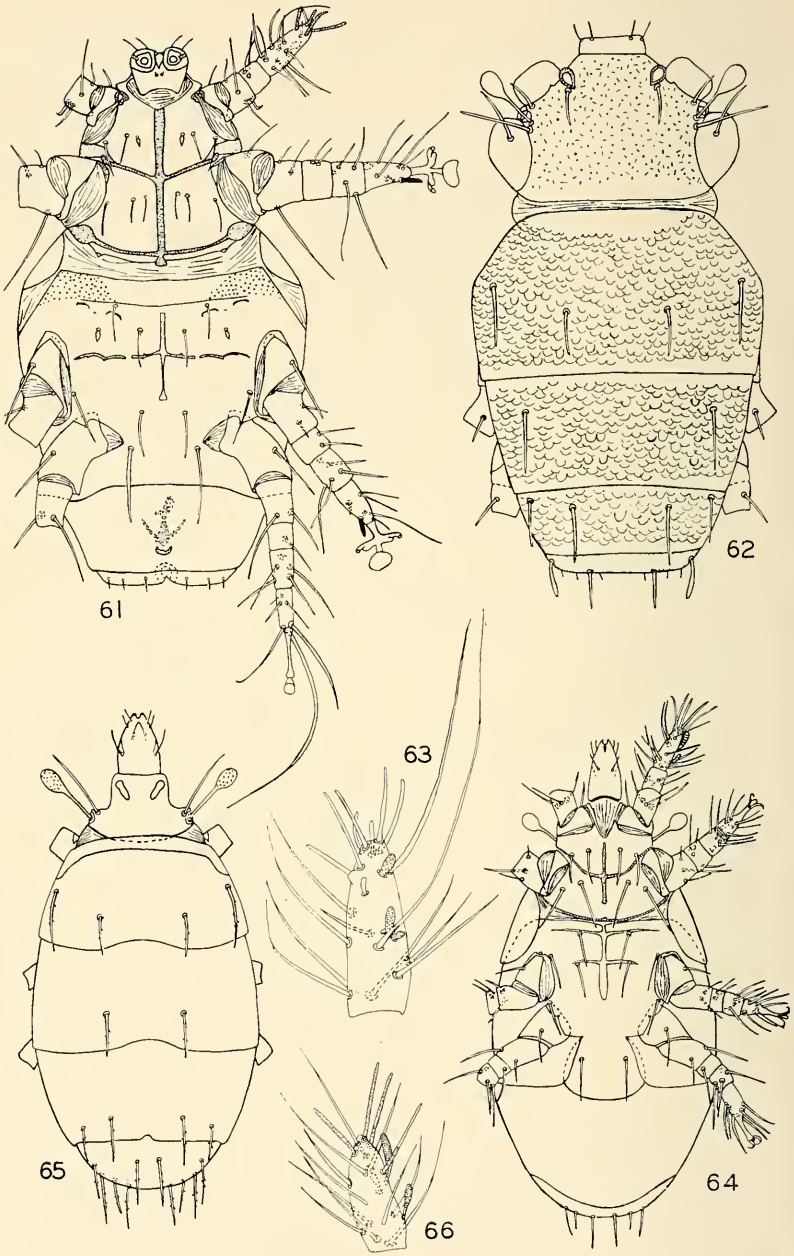
FIGS. 51-53. *Siteroptes* (*Siteroptoides*) *absidatus*, holotype female. Fig. 53, right tibiotarsus I, ventral aspect.

FIGS. 54-56. *Pediculaster* (*Acarothorectes*) *curculionium*, holotype female. Fig. 56, right tibiotarsus I, ventral aspect.



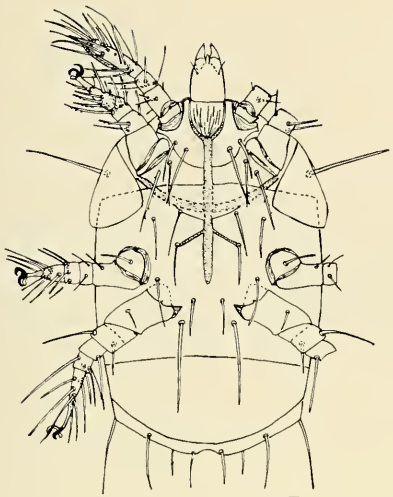
FIGS. 57-58. *Pediculaster* (*Pediculaster*) *americanus,* female. Composite, lectotype and paratype no. 1.

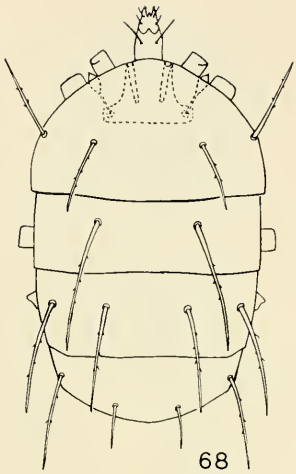
FIGS. 59-60. *Pygmephorus* sp. nr. *spinosus,* female, Posey Co., Indiana, from nest of *Blarina brevicauda.*

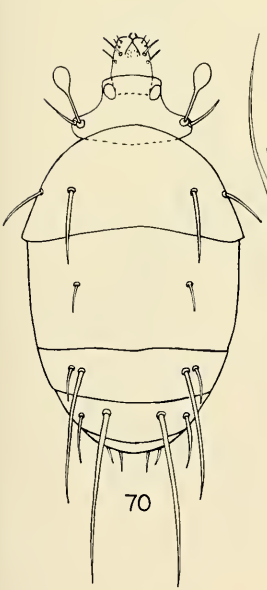


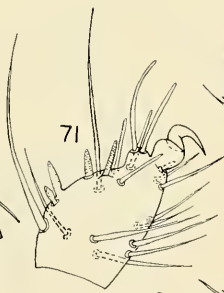
FIGS. 61-63. *Microdispodides pholidotus*, female. Composite, holotype and paratype no. 1. Fig. 63, right tibiotarsus I of holotype, dorsal aspect.

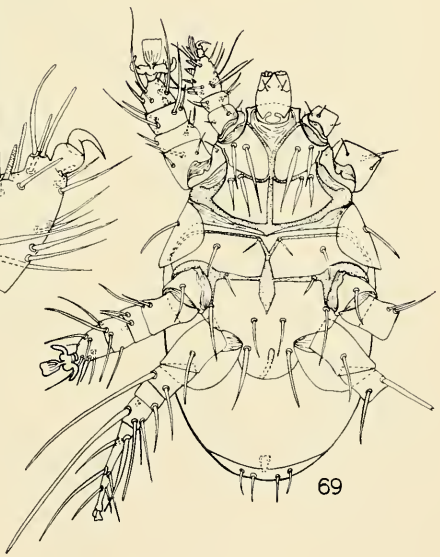
FIGS. 64-66. *Microdispus* (*Premicrodispus*) *chandleri*, holotype female. Fig. 66, left tibiotarsus I, ventral aspect.





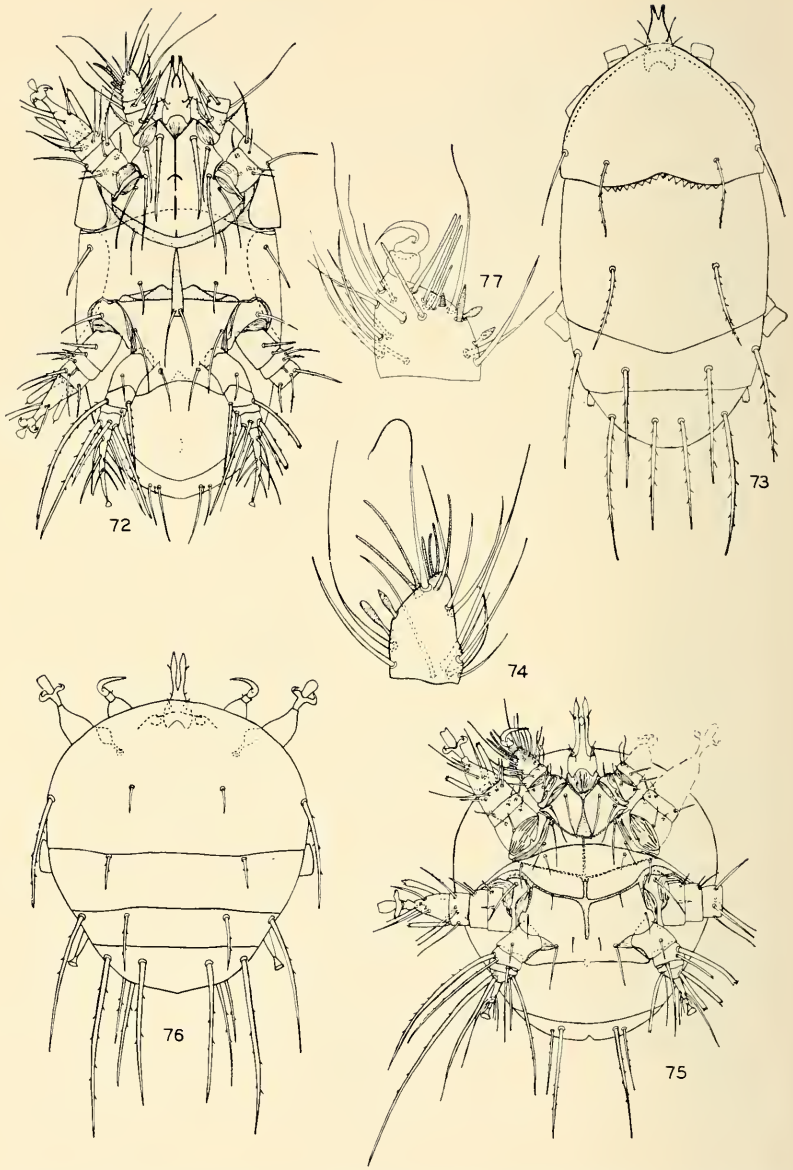






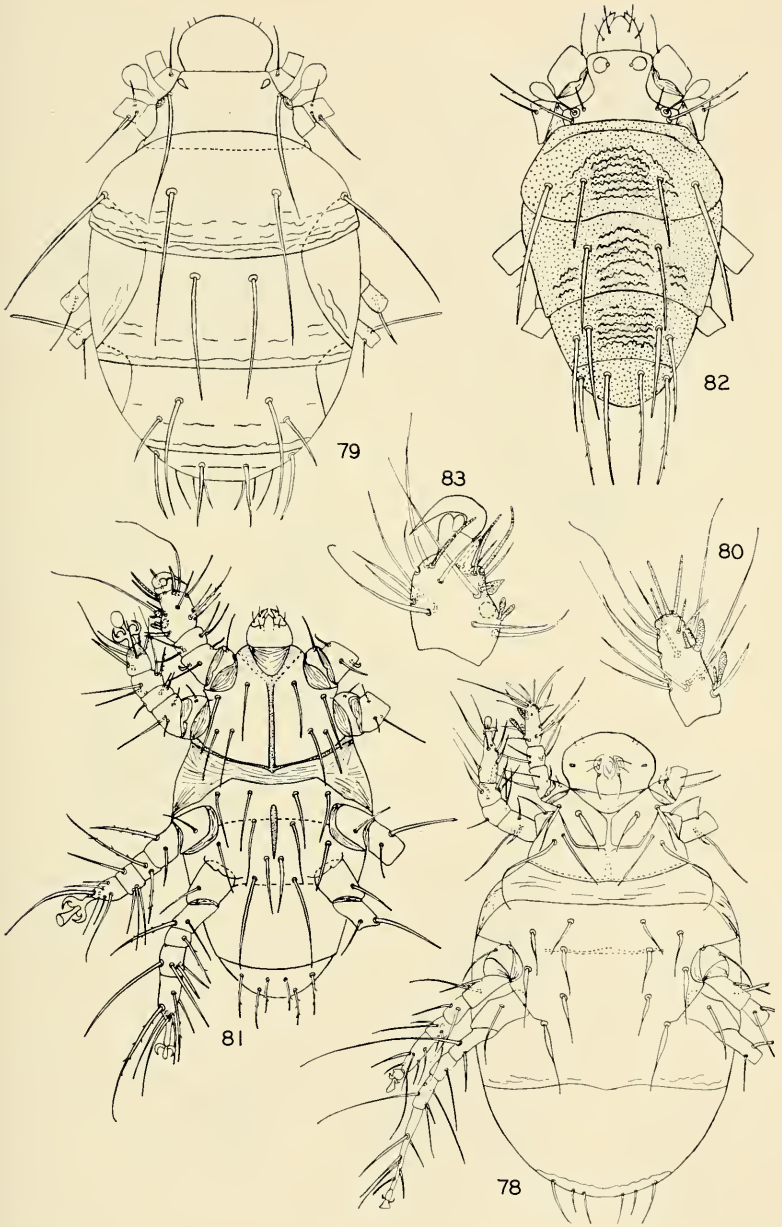
FIGS. 67-68. *Microdispus* (*Microdispus*) sp. female, Rio Caraguata, Matto Grosso, Brazil.

FIGS. 69-71. *Myrmecodispus dorylinis*, holotype female. Fig. 71, left tibiotarus I, dorsal aspect.



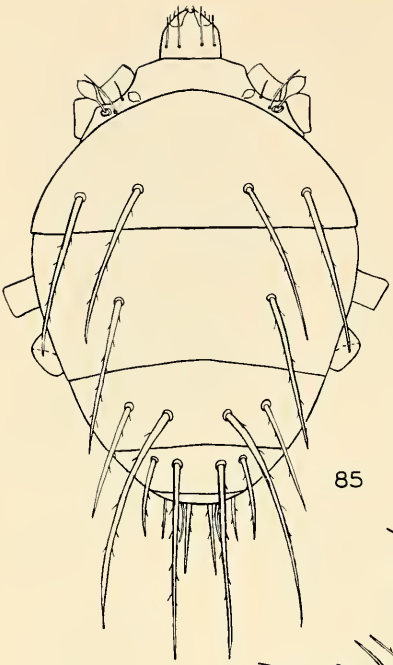
FIGS. 72-74. *Glyphidomastax rettenmeyeri,* holotype female. Fig. 74, right tibiotarsus I, ventral aspect. Shape of upper clavate solenidium is in error, see description.

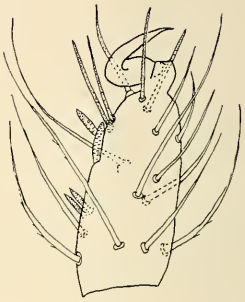
FIGS. 75-77. *Perperipes ornithocephala,* female. Composite, holotype and paratype no. 12. Fig. 77, right tibiotarsus I of holotype, dorsal aspect.



FIGS. 78-80. *Peponocara cathistes,* holotype female. Fig. 80, right tibiotarsus I, dorsal aspect.

FIGS. 81-83. *Parapygmephorus* (*Sicilipes*) *halictinis,* holotype female. Fig. 83, left tibiotarsus I, ventral aspect.





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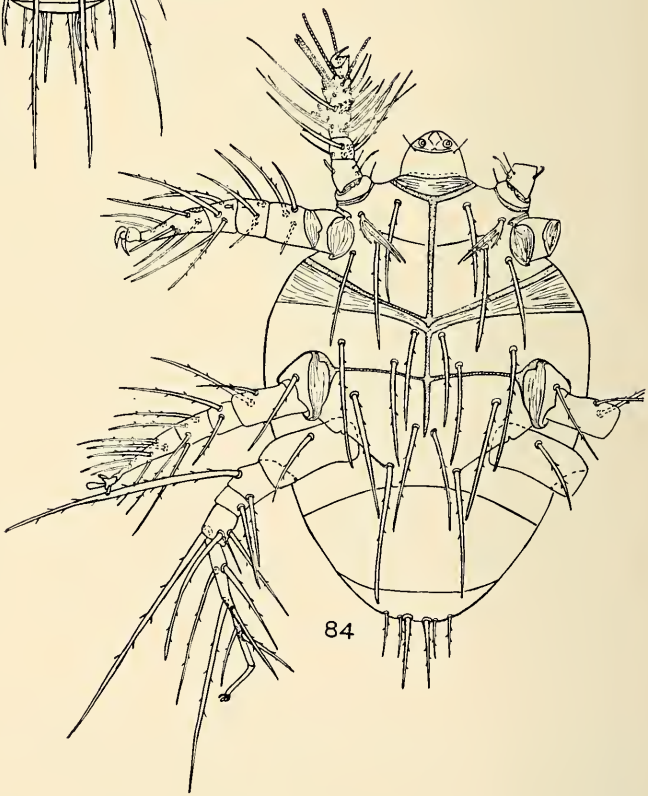

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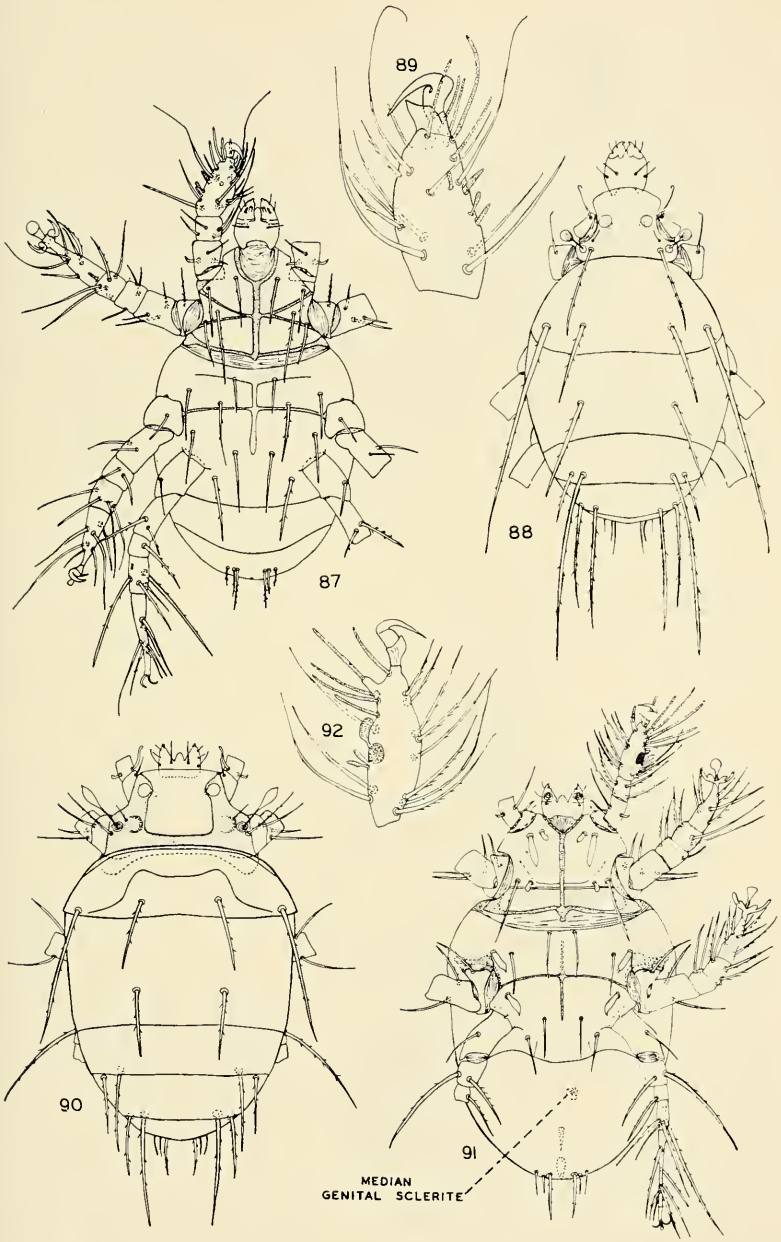
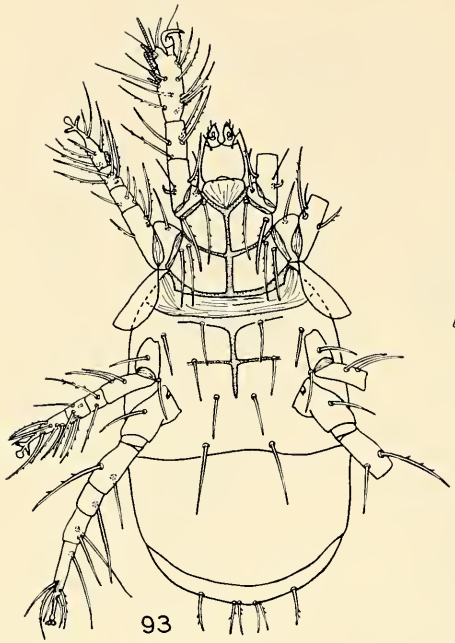
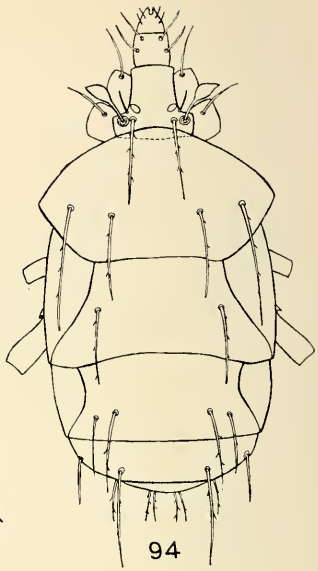
FIGS. 84-86. *Parapygmephorus* (*Petalomium*) *krczali*, female. Composite, holotype and paratype no. 2. Fig. 86, right tibiotarsus I of paratype no. 1, dorsal aspect.

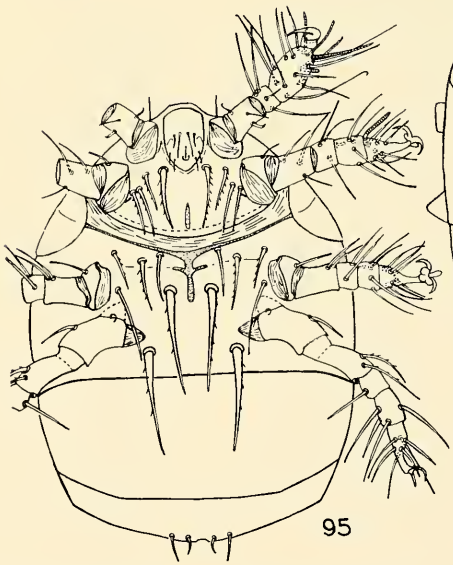


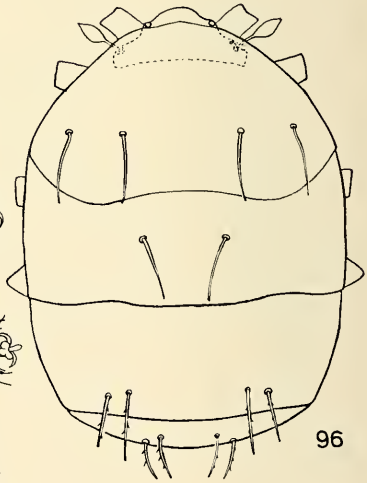
FIGS. 87-89. *Parapygmephorus* (*Parapygmephorus*) *natalensis*, female. Composite, holotype and paratype no. 2. Fig. 89, right tibiotarsus I of holotype, dorsal aspect.

FIGS. 90-92. *Acinogaster marianae*, holotype female. Fig. 92, left tibiotarsus I, dorsal aspect.



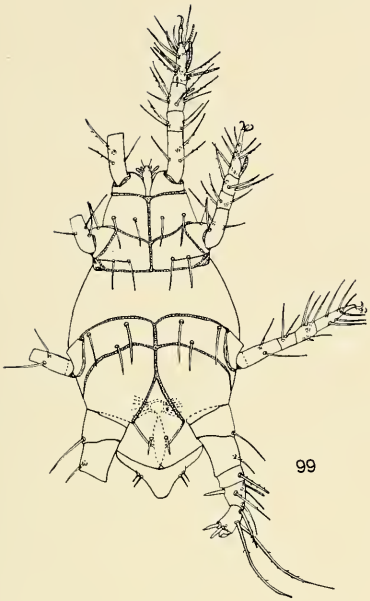


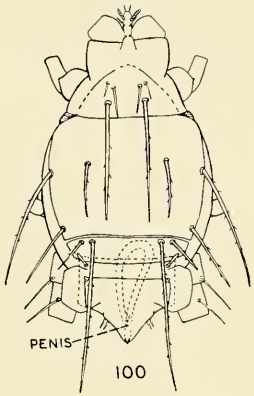


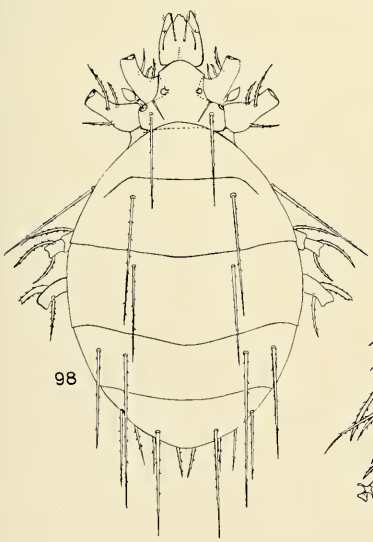


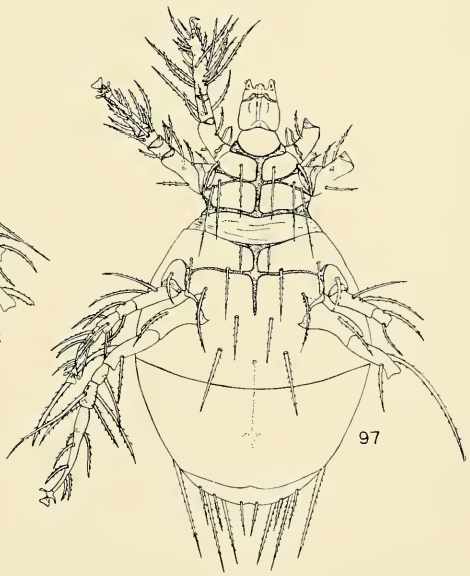
FIGS. 93-94. *Pseudopygmephorus* sp. nr. *tarsalis*, female, Lawrence, Kansas, leaf mold.

FIGS. 95-96. *Neopygmephorus* (*Allopygmephorus*) sp. nr. *matthesi*. Female, Muscotah, Kansas, from *Paracymus* in water.









Figs. 97-100. *Neopygmephorus* (*Neopygmephorus*) sp. Lawrence, Kansas, in rodent cache under log. Figs. 97-98, female. Figs. 99-100, male.

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XLV] JUNE 7, 1965 [No. 3

A Revision of the Banded Subgenera of *Nomia* in America (Hymenoptera: Halictidae)[1]

BY

DAVID W. RIBBLE

ABSTRACT: This paper is a monographic revision of the bee subgenera *Curvinomia* and *Acunomia* of the genus *Nomia* in North America. *Acunomia* occurs only in North America, while *Curvinomia* occurs also in the Old World. Nine species and three subspecies are treated; one species, *Nomia* (*Curvinomia*) *angustitibialis*, is described as new. Seven names have been placed in synonymy for the first time, and three other names occur in new subgeneric combinations, one of these being elevated from previous synonymy. Although primarily a taxonomic study, this work brings together available data concerning distribution, biologies of several species, and flower preferences. A total of 4,781 bees were examined during this study.

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1. Contribution No. 1188 from the Department of Entomology, The University of Kansas, Lawrence, Kansas; submitted in partial fulfillment of the requirements for the degree of Master of Arts.

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INTRODUCTION

This paper is a taxonomic revision of the American subgenus *Acunomia* and the American species of *Curvinomia* of the genus *Nomia*. Species of these two subgenera can be differentiated from any other North American bees by their brilliant, metallic colored abdominal bands. Other subgenera may have abdominal bands of pale pubescence but do not have integumental bands. The subgenera of *Nomia* are in a state of taxonomic confusion, and it seems best not to make any subgeneric changes until the large African fauna has been more fully studied (Michener, 1961). When this has been done it is likely that the subgenera *Acunomia*, *Curvinomia* and *Hoplonomia* will be included in *Nomia* s. str. All of them have colored integumental abdominal bands. I follow Cross (1958a) in the placement of the species in *Acunomia* and *Paranomina* (= *Curvinomia*).

There have been nineteen specific and four subspecific names proposed for *Acunomia* and the North American species of *Curvinomia*. When this study was begun, fourteen specific and three subspecific names were being used. I consider nine species and three subspecies as valid. Seven names have been placed in synonymy for the first time, and one species is described as new. Three other names appear in new subgeneric combinations, one of these being elevated from previous synonymy. A total of 4,781 bees were examined during this study.

Acunomia seems very closely related to *Curvinomia* and probably arose from it since our *Curvinomia* became separated from the Palearctic fauna (Cross, 1958a). Since *Curvinomia* reaches only slightly above 44° north latitude in North America, our species must have been separated from the Palearctic ones at least since the Pliocene, for that was the last time portions of Alaska had a temperate climate (Hibbard, 1960).

ACKNOWLEDGMENTS

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METHODS

The synonymy is given in abbreviated form, since the complete reference can be found in the bibliography. All papers known to refer to the species or subspecies in question are listed, whether or not they are strictly taxonomic in nature. After each citation is an abbreviation or word in parentheses that indicates the main emphasis of the paper as it pertains to the particular species or subspecies. "Taxonomic" is abbreviated "tax."; if followed by ♀ there is a description of the female, and if by ♂, a description of the male is given. The other abbreviations used are as follows: alf. = alfalfa pollination, biol. = biology, fls. = flower record, para. = parasites and predators, and rec. = locality record.

The method of Moure and Michener (1955) in numbering characters in the descriptions is used for easy comparison. Specific and subspecific descriptions use the same numbers but separate numbering systems are used for the two subgenera. The wings are measured from the tip of the marginal cell to the wing base along the anterior margin. Tergum 1 refers to the first metasomal tergum, and the other terga and sterna are numbered accordingly. This system does not correspond to the strictly morphological system, in which the first metasomal tergum would be abdominal tergum 2, but it is generally used (Moure and Michener, 1955) and presents less opportunity for confusion.

In using the terms gonocoxite, gonostylus, etc., I do not wish to imply the appendicular origin of these structures, but am merely following with established practice. The terms used in the descriptions of sterum 5 and the genitalia are shown in figures 24 and 30.

When referring to Cockerell's types, currently accepted terms for the kinds of types will be used. Cockerell used type when referring to a holotype and his cotype is the same as paratype.

In the lists of localities, an asterisk refers to a record in the literature. A question mark indicates a locality that was not found on any map examined. After the locality the number of each sex examined from that locality is given. If no number precedes the sex symbol, there is but one specimen of that sex. An attempt was made to use standardized, easily found place names. When needed, more specific information is given in parentheses for certain localities.

In the lists of flower records, those taken from the literature are followed by an asterisk. After the name of each flower is given the number of specimens of each sex taken. If no number precedes the sex symbol there is but one specimen of that sex. An attempt was made to use currently accepted plant names.

TAXONOMIC CHARACTERS

In the descriptions all variations found have been described, even though not found to be taxonomically significant. In the males the hind tibiae, genitalia and the fifth modified sterna offer the best specific characters. In the females the punctation of the metasomal terga provide the best specific characters. The integumental color was found to be highly variable, ranging from black to red-brown in all species. The color varies in a haphazard fashion. Aging in museums may have some effect on color. In general the very old specimens were the reddest, while those collected recently were the blackest, although there was a little variation in specimens of the same age. It is not known whether it is light, paradichlorobenzene or some other factor that causes museum specimens to lose their black color. The metepisternum is highly variable in wrinkle size and pattern. The anterior groove of the propodeum is highly variable in shape and wrinkle pattern. The color of the abdominal bands varies greatly; therefore, this character should be used with caution. These bands tend to lose their color permanently if they become wet, as in a relaxing or killing jar. Band width is a more reliable character. The amount of black hair on the metasoma is highly variable. On older specimens the hair is often worn away, especially on the clypeus and metanotum, and these specimens may not fit the descriptions in this respect. In describing the punctation of the metasomal terga it is the central portion of the tergum that is referred to, unless otherwise stated.

KEY TO THE SPECIES AND SUBSPECIES OF *Acunomia* AND NORTH AMERICAN *Curvinomia*

1. Males: Antenna thirteen-segmented; hind tibia and femur enlarged; fifth metasomal sternum with two large hairy pads 2
   Females: Antenna twelve-segmented; hind tibia and femur unmodified; fifth metasomal sternum without hairy pads 13
2. Hind tibia produced anteriorly and distally into large lobe hiding all or almost all of tibial spurs in side view (fig. 7); antenna tapering and if bent backward, reaching beyond thorax (subgenus *Acunomia*) 3
   Hind tibia triangular, not hiding most of tibial spurs in side view (fig. 1); antenna not tapering and if bent backward not reaching beyond thorax (subgenus *Curvinomia*) 7
3. Large, front wing length (see section on methods) 10.0 mm. or more; mandible with large rounded lobe on posterior margin (species *nortoni*) .. 4
   Medium-sized, front wing length less than 10.0 mm.; mandible with toothlike lobe or lobe absent on posterior margin 5
4. Hind tibial lobe with raised area of outer surface limited to basal half, raised area not forming distinct ridge; anterior margin of general area, along eye, bare ..... *n. nortoni*
   Hind tibial lobe with raised area on outer surface extending toward tip, raised area forming distinct ridge; anterior margin of general area, along eye, with short, appressed, plumose hairs ..... *n. cressoni*
5. Hind tibial lobe with apex rounded (fig. 9); pronotum without posterior, dorsal carina (species *melanderi*) 6
   Hind tibial lobe with deep apical emargination (fig. 11); pronotum with strong posterior, dorsal carina ..... *robinsoni*
6. Colored band on tergum 1 broken or much reduced toward center. *m. melanderi*
   Colored band on tergum 1 present and not reduced toward center. *m. howardi*
7. Clypeal margin with median tooth ..... *angustitibialis*
   Clypeal margin without median tooth 8
8. Punctures on tergum 4 close, minute, much smaller than those on tergum 2 9
   Punctures on tergum 4 not close, large, about the same size as those on tergum 2 11
9. Hind femur three times as long as broad ..... *maneei*
   Hind femur twice as long as broad 10
10. Posterior tibia with apex yellow (fig. 5) ..... *foxii*
    Posterior tibia with only tip of lobe yellow (fig. 2) ..... *fedorensis*
11. Transverse groove on tergum 2 shallow and U-shaped in cross-section .. 12
    Transverse groove on tergum 2 deep with anterior face nearly vertical, posterior face sloping gently upward ..... *t. tetrazonata*
12. Apical, depressed area on tergum 2 about as wide as rest of postgradular area ..... *t. uvaldensis*
    Apical, depressed area on tergum 2 less than one-half as wide as rest of postgradular area ..... *universitatis*
13. Middle tibial spur finely and evenly serrate along entire length (subgenus *Curvinomia*) 18
    Middle tibial spur with few, uneven, coarse teeth along apical third (subgenus *Acunomia*) 14
14. Tergum 1 with apical colored band (species *melanderi*) 15
    Tergum 1 without apical colored band 16

15. Colored band on tergum 1 one-third width of band on tergum 2. *m. melanderi*
Colored band on tergum 1 one-half width of band on tergum 2. *m. howardi*
16. Large, front wing length (see section on methods) more than 8.0 mm.; pronotum without posterior, dorsal carina (species *nortoni*) 17
Medium-sized, front wing length less than 8.0 mm.; pronotum with posterior, dorsal carina ..... *robinsoni*
17. Anterior margin of genal area, along eye, bare ..... *n. nortoni*
Anterior margin of genal area, along eye, with short, appressed, plumose hairs ..... *n. cressoni*
18. Raised areas on terga 1 to 3 nearly impunctate and highly polished ... *foxii*
Raised area on terga 1 to 3 usually well punctured and not polished ... 19
19. Tergum 3 with punctures close and minute, much smaller than those in center of tergum 2 20
Tergum 3 with punctures medium to large, not close and not much smaller than those in center of tergum 2 21
20. Postgradular area depressed below level of pregradular area on tergum 2. *maneei*
Postgradular area not depressed below level of pregradular area on tergum 2 ..... *fedorensis*
21. Centers of terga 1 and 2 with punctures minute, much finer than those of mesocutum ..... *t. uvaldensis*
Centers of terga 1 and 2 with punctures fine to coarse, not much finer than those of mesoscutum 22
22. Colored band on tergum 3 narrow, 0.33 mm. in width 23
Colored band on tergum 3 wide, 0.50 mm. or more in width. *angustitibialis*
23. Wing length about 9 mm.; midwestern United States ..... *universitatis*
Wing length about 7 mm.; southwestern United States and Mexico. *t. tetrazonata*

Subgenus *Curvinomia* Michener

Nomia (*Paranomia*) Friese, 1897, p. 48 (not *Paranomia* Conrad, 1860) (type species: *N. chalybeata* Smith); Cockerell, 1905, p. 322; Cockerell, 1910b, p. 289; Cockerell, 1930, p. 12; Blair, 1935, pp. 208 and 211; Sandhouse, 1943, p. 584.

Paranomia: Ashmead, 1899, p. 88.

Nomia (*Paranomina*) Michener, 1944, p. 251 (not *Paranomina* Hendel, 1907), (new name for *Paranomia* Friese); Cross, 1958a, p. 1263.

Nomia (*Curvinomia*) Michener, 1944, p. 251 (type species: *N. californiensis* Michener, = *N. t. tetrazonata* Cockerell); Michener, 1951, p. 1127.

Except for the original reference, only papers dealing with North American *Curvinomia* are cited in the synonymy above. Since *Paranomia* and *Paranomina* are preoccupied, this subgenus takes the name *Curvinomia,* the only other available name.

The characters that separate the North American *Curvinomia* from *Acunomia* are given below:

MALE. Antenna not tapering and not reaching beyond thorax when bent backward, last flagellar segment blunt or angular. Posterior tibia triangular in shape, not hiding most of tibial spurs in side view (fig. 1). Tergum 1 never with colored band. Sternum 3 without ventrolateral process. Sternum 5 with setae in row behind lateroapical hairy pads not completely fused; median apical process arising from median longitudinal ridge only posteriorly (fig. 12). Penis valve without ventral opening (fig. 18); gonostylus without small, inward-pointing, hooklike process at base.

FEMALE. Middle tibial spur finely and evenly serrate along entire length. Tergum 1 never with colored band.

Nomia (*Curvinomia*) *maneei* Cockerell

(Figs. 1, 12 and 18; Map 1; Table 5)

Nomia maneei Cockerell, 1910a, p. 276 (tax., ♀); Cockerell 1930, p. 13 (tax.); Cockerell, 1934b, p. 7 (tax.); Brimley, 1938, p. 457 (rec.); Fattig, 1943, p. 6 (para.); Muesebeck *et al.*, 1951, p. 761 (para.).

Nomia (*Acunomia*) *maneei:* Michener, 1951, p. 1128 (cat); Mitchell, 1960, p. 508 (tax., ♂, ♀).

Paranonia [sic] maneei: Snyder, 1957, p. 58 (rec.).

Nomia (*Paranomina*) *maneei:* Cross, 1958, p. 1266 (tax.).

This species can be differentiated from other North American *Curvinomia* by the minute, close punctures on terga 3 and 4, the narrow, bright green abdominal hands, and in the male by the only slightly modified hind femur and tibia.

MALE. *Structure:* (1) Clypeal margin broadly rounded in center with narrow submarginal, impunctate area; clypeus with large, rounded, longitudinal ridge. (2) Metepisternum with many fine to a few coarse wrinkles. (3) Propodeum with fine punctures on posterior face. (4) First m-cu interstitial with to several vein widths basal from first r-m. (5) Posterior femur three times as long as broad. (6) Posterior tibia slightly expanded toward apex (fig. 1). (7) Tergum 1 with medium-sized punctures except for band of minute punctures at base of apical, depressed, hyaline portion; median width of band one-half width of depressed area. (8) Tergum 2 with punctures like those of center of tergum 1; groove between postgradular and pregradular areas deep, its anterior face nearly vertical, posterior face sloping gently upward. (9) Terga 3

and 4 much more finely punctate than center of tergum 1, except raised area of tergum 3 which has punctures like those of tergum 1. (10) Sternum 5 with lateral, longer part of median, apical process about as long as wide and rounded at apex, processes widely separated; lateroapical hairy pads with hairs sometimes meeting along midline, hairs in center of pad not darkened, pads half round in shape; median, basal emargination much more than twice as wide as deep, V-shaped (fig. 12). (11) Gonocoxite with apex of dorsal recurved part bent outward and rounded. (12) Gonostylus with plate at its base with small bumps on inner side. (13) Exposed part of penis valve two-thirds as wide as long, tip broad and pointed, inner subapical margin with small rounded lobe, extreme lateral part with anteriorly pointing tooth, anteroventral process J-shaped (fig. 18). *Pubescence:* (14) Terga 4 to 7 with some black hairs, sometimes absent on tergum 4; tergum 3 with hairs all white. (15) Gonocoxite with dorsal recurved part with large, stout hairs at tip arising from well behind inner margin. *Color:* (16) Mandible translucent orange to red-brown with red tip and black to orange base. (17) Antenna orange to red-brown below, black to red-brown above. (18) Legs brown to red-brown with tarsi and tip of hind tibial lobe which may be orange to yellow. (19) Stigma darkened, darker in color than most wing veins. (20) Colored band of tergum 2 about 0.25 mm. in width; color bright green with pink or purple iridescence.

Female. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is broadened distally. (22) Clypeal margin truncate in center. (23) Head and thorax with fine punctures; mesoscutum with spaces between punctures minutely roughened. (24) Metepisternum with several medium to fewer coarse wrinkles. (25) Tergum 1 with close, fine punctures except for band of minute punctures at base of apical, depressed, hyaline portion; median width of band three-fourths width of depressed area; center of tergum not highly polished. (26) Tergum 2 with punctures same size as those of center of tergum 1 or smaller; tergum 2 not highly polished; postgradular area abruptly depressed below level of pregradular area. (27) Terga 3 and 4 with minute, close punctures, much smaller than those of tergum 2. *Pubescence:* (28) Body hairs white with some black hairs on terga 2 to 6. *Color:* (29) Antenna orange to red-brown below, black to red-brown above. (30) Stigma darkened, darker in color than most wing veins. (31) Colored band of tergum 2 about 0.33 mm. in width; color bright green with pink or purple iridescence.

TYPE MATERIAL. The female holotype of *maneei*, Southern Pines, North Carolina, June 19, 1909 (A. H. Manee), could not be located. This specimen was in the Birkman collection at the time of description. I have seen a female in the Illinois State Natural History Survey collection and another female in the Citrus Experiment Station collection that bear these same label data, but neither of these specimens seems to be the holotype of *maneei*. The Illinois State Natural History Survey collection also has two males with the same label data. Since Cockerell apparently described *maneei* from a single female these other specimens are only topotypes. The designation of a neotype does not seem warranted.

RANGE. *N. maneei* ranges from North Carolina to Florida westward nearly to the Mississippi River (map 1). One specimen has been collected in New Jersey. This range does not approach that of any other *Curvinomia*.

LIST OF LOCALITIES. ALABAMA. Colbert Co.: Sheffield ♀. FLOIRDA. Alachua Co.: Gainesville ♀; Dade Co.: Miami ♂; Duval Co.: Jacksonville Beach ♀; Levy Co. 2♂; Orange Co.: Winter Park ♂; Pasco Co.: Lacoochee ♂; Polk Co.: Fort Meade ♂; Suwanee Co.: Suwanee Springs ♀♂. GEORGIA. Dade Co.: Head River 3♀2♂; Decatur Co.: Bainbridge ♂, Spring Creek 2♂; DeKalb Co.: Stone Mountain ♂; Dougherty Co.: Albany ♂; Floyd Co.: Rome ♀♂; Franklin Co.: Royston 2♂; Stephens Co.: Toccoa ♀; Warren Co.: Warrenton ♂. MISSISSIPPI. Harrison Co.: Gulfport ♀; Lowndes Co.: Columbus ♀. NEW JERSEY. Burlington Co.: Rancocas ♀. NORTH CAROLINA. Craven Co.: Croatan 2♂; Harnett Co.: Lillington ♀5♂; Lenoir Co.: LaGrange ♀; Macon Co.: Highlands (Horse Cove) ♂; McDowell Co.: Marion ♀; Moore Co.: Southern Pines 8♀18♂; New Hanover Co.: Carolina Beach 9♂, Wilmington 2♀♂, Wrightsville Beach ♂; Onslow Co. 2♀: Dixon;* Richmond Co.: Hoffman 4♀; Swain Co.: Bryson City 10♀2♂; Wake Co.: Raleigh 2♀. SOUTH CAROLINA. Abbeville Co.: Calhoun Falls ♂; Aiken Co.: Aiken ♂.

FLOWER RECORDS. ASCLEPIADACEAE: *Asclepias tuberosa* 9♂. LEGUMINOSAE: *Desmodium ciliare* ♀♂, *Galactia* sp. 2♀♂, *Lespedeza capitata* ♂, *L. repens* 10♀♂, *Phaseolus polystachios* ♀3♂, *Strophostyles* ♀. POLYGONACEAE: *Eriogonum baileyi* ♂.

PARASITES. *Pseudomethoca vanduzeei* (Hymenoptera: Mutillidae) has been recorded from the pupa of *maneei* (Fattig, 1943).

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults.

Nomia (Curvinomia) fedorensis Cockerell

(Figs. 2, 13 and 19; Map 2; Table 5)

Nomia foxii: Birkman, 1899, p. 244 (rec.) (misidentification).

Nomia fedorensis Cockerell, 1910a, p. 277 (tax., ♀, ♂); Cockerell, 1930, p. 13 (tax.); Cockerell, 1934b, p. 4 (biol.).

Nomia (Acunomia) fedorensis: Michener, 1951, p. 1127 (cat.).

Nomia (Paranomina) fedorensis: Cross, 1958a, p. 1266 (tax.).

This species can be differentiated from other North American species of *Curvinomia* by the very small, close punctures on terga 3 and 4, the bright emerald green abdominal bands, and in the male by the greatly expanded hind femur and tibia.

Male. *Structure:* (1) Clypeal margin broadly rounded in center with narrow submarginal, impunctate area; clypeus with distinct longitudinal carina. (2) Metepisternum with many fine to fewer medium wrinkles. (3) Propodeum with medium-sized punctures on posterior face. (4) First m-cu nearly interstitial with to several vein widths basal from first r-m. (5) Posterior femur twice as long as broad. (6) Posterior tibia greatly expanded toward apex (fig. 2). (7) Tergum 1 with coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-third to one-half width of depressed area. (8) Tergum 2 with punctures like those of center of tergum 1; groove between postgradular and pregradular area deep and V-shaped. (9) Terga 3 and 4 much more finely punctate than center of tergum 1, except raised area of tergum 3 which has punctures like those of tergum 1. (10) Sternum 5 with lateral longer part of median, apical process absent, process one-half as long as wide and truncate at apex, processes nearly converging along midline; lateroapical hairy pads with hairs sometimes meeting along midline, hairs in center of pad not darkened, pads half round in shape; median, basal emargination from as wide as deep to twice as wide as deep, U-shaped, or tending toward V-shaped (fig. 13). (11) Gonocoxite with apex of recurved part bent outward and rounded. (12) Gonostylus with plate at its base papillose on inner side. (13) Exposed part of penis valve two-thirds as wide as long, tip broad and pointed, inner subapical margin with small rounded lobe, extreme lateral part with anteriorly pointing tooth, anteroventral process J-shaped (fig. 19). *Pubescence:* (14) Terga 3 to 7 with some black hairs. (15) Gonocoxite with dorsal recurved part with large, stout hairs at tip arising well behind inner margin. *Color:* (16) Mandible translucent yellow

to red-brown with red tip and brown to yellow base. (17) Antenna yellow to orange below, red-brown to orange above. (18) Legs black to red-brown with tip of hind tibial lobe yellow. (19) Stigma light in color like most wing veins. (20) Colored band of tergum 2 about 0.33 mm. in width; color bright emerald green with pink, purple, gold or yellow iridescence.

FEMALE. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is broadened distally. (22) Clypeal margin truncate in center. (23) Head and thorax with fine punctures; mesoscutum with spaces between punctures smooth. (24) Metepisternum with many fine to fewer medium-sized wrinkles. (25) Tergum 1 with close, coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-half width of depressed area; center of tergum not highly polished. (26) Tergum 2 with punctures same size as those of center of tergum 1 or smaller; tergum 2 not highly polished; postgradular area not depressed below level of pregradular area. (27) Terga 3 and 4 with minute, close punctures, much smaller than those on tergum 2. *Pubescence:* (28) Body hairs white or yellowish with some black hairs on terga 3 to 6. *Color:* (29) Antenna orange below, black to red-brown above. (30) Stigma darkened or light in color like most wing veins. (31) Colored band on tergum 2 about 0.33 mm. in width; color bright emerald green with purple, red or pink iridescence.

VARIATION. Little variation has been noted in the characters studied in the few specimens of this species examined. A female from Vera Cruz, Mexico, has the yellowish hairs mentioned in character 28; other specimens have whitish hairs.

TYPE MATERIAL. The female holotype of *fedorensis,* Fedor, Lee County, Texas, June 7, 1909 (G. Birkman), is in the U. S. National Museum, type number 55864. A male paratype is also there, with the same label data except the date (June, 1910).

RANGE. *N. fedorensis* occurs in southern and central Texas with a few specimens known from southwestern Kansas and Vera Cruz, Mexico (map 2).

LIST OF LOCALITIES. KANSAS. Clark Co. 3 ♀ 7 ♂. TEXAS. Atascosa Co.: Lytle ♀ 4 ♂; Bastrop Co.: McDade 2 ♂; Bexar Co. 11 ♀ ♂; Brooks Co.: Fulfurrias ♂; Cameron Co.: Boca Chica ♂; Dimmit Co.: Carrizo Springs ♀; Eastland Co.: Romney ♀ 4 ♂; Goliad Co. ♀: Weser ♀; Kenedy Co.: Sarita (18 mi. S.) ♂,

(29 mi. S.) ♀4♂; Lee Co.: Fedor 4♀3♂; San Saba Co.: San Saba Camp ♀. MÉXICO. Veracruz: Veracruz ♀3♂.

FLOWER RECORDS. COMPOSITAE: *Gaillardia* ♂, *Helianthus* sp. ♂, genus? ♀. LEGUMINOSAE: *Cassia* sp.,* *Dalea grisea* ♀4♂, *Mimosa,* sp. 2♀♂, *Rhynchosia americana,** *Tephrosia virginiana* ♂.

BIOLOGY. Cockerell (1934b) mentions a nesting site of *fedorensis.* Nothing else is known of the biology of this species.

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults.

Nomia (*Curvinomia*) *universitatis* Cockerell

(Figs. 3, 14 and 20; Map 1; Table 5)

Nomia punctata var. (?) Fox, 1893, p. 134 (not Smith, 1875) (tax., ♀); Cockerell, 1930, p. 14 (tax.).

Nomia foxii Dalla Torre, 1896, p. 167 (new name for *N. punctata* Fox) (in part) (cat.); Cockerell, 1906a, p. 298 (in part) (rec.) (misidentifications).

Nomia punctata: Cockerell, 1898d, p. 31 (in part) (tax.); Swenk, 1907, p. 293 (rec.).

Nomia universitatis Cockerell, 1908, p. 334 (tax., ♂); Cockerell, 1910a, p. 277 (tax.); Cockerell & Robbins, 1910, p. 194 (tax.); Cockerell, 1925b, p. 233 (rec.); Blair, 1930, p. 17 (tax.); Michener, 1936, p. 4 (tax.).

Nomia (*Paranomia*) *universitatis:* Cockerell, 1910b, p. 297 (tax.); Cockerell, 1930, p. 14 (tax.).

Nomia (*Acunomia*) *universitatis:* Michener, 1951, p. 1128 (cat.).

Nomia universatis: Stevens, 1951, p. 64 (*lapsus calami*) (tax.).

Nomia (*Paranomina*) *universitatis:* Cross, 1958a, p. 1266 (tax.).

Fox described *punctata* from three female specimens, one from each of the following localities: Denver, Colorado; Vega San Jose, New Mexico; and Big Stone City, South Dakota. Only the specimen from New Mexico has been located. This specimen belongs to the species that has been considered *mesillensis* (= *foxii*), the least punctate North American banded *Nomia.* The other specimens probably were *universitatis,* since that is the only *Curvinomia* known to occur in northern Colorado or South Dakota. The much larger *N. nortoni* is the only similar bee known from the same area. Fox recognized *nortoni* and included it in his key (1893). Fox (1893) considered one of the syntypes of *punctata* a possible "variety" because of its strong punctation. Therefore, the specimen

from New Mexico could not be this "variety." Since *universitatis* is strongly punctate it is here considered as Fox's "variety." Cockerell (1908, 1930) came to a similar conclusion. One problem with this reasoning is that Fox's variety included a single specimen, but on the basis of the localities stated above, both remaining syntypes should be strongly punctate. This matter can be settled only if these two missing specimens are found, which seems unlikely.

N. universitatis can be distinguished from other North American *Curvinomia* by its coarse punctation and narrow abdominal bands.

MALE. *Structure:* (1) Clypeal margin broadly rounded in center, with wide submarginal, impunctate area; clypeus with weak longitudinal carina. (2) Metepisternum with many fine to a few coarse wrinkles. (3) Propodeum with coarse punctures on posterior face. (4) First m-cu several vein widths basal from first r-m. (5) Posterior femur two and one-half times as long as broad. (6) Posterior tibia greatly expanded toward apex (fig. 3). (7) Tergum 1 with coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-third width of depressed area to reduced to a few scattered punctures. (8) Tergum 2 with punctures like those of center of tergum 1; groove between postgradular and pregradular area shallow and U-shaped. (9) Terga 3 and 4 with punctures like those in center of tergum 1. (10) Sternum 5 with lateral, longer part of median, apical process twice as long as wide and truncate to rounded at apex; processes widely separated; lateroapical hairy pads with hairs considerably overlapping along midline, hairs in center of pad not darkened, pads crescent-shaped; median basal emargination about twice as wide as deep, U-shaped tending towards V-shaped (fig. 14). (11) Gonocoxite with apex of dorsal recurved part bent outward and rounded. (12) Gonostylus with plate at its base with small bumps on inner side. (13) Exposed part of penis valve two-thirds as wide as long, tip broad and pointed, inner subapical margin rounded, extreme lateral part with anteriorly pointing tooth, anteroventral process J-shaped (fig. 20). *Pubescence:* (14) Terga 5 to 7 with some black hairs, sometimes absent on tergum 5; terga 3 and 4 with hairs all white. (15) Gonocoxite with dorsal recurved part with large, stout hairs at tip arising from well behind inner margin. *Color:* (16) Mandible red-brown with red tip and black base. (17) Antenna orange to red-brown below, black above. (18) Legs red-brown with tarsi and hind tibial lobe yellow. (19) Stigma darkened or light in

color like most wing veins. (20) Colored band of tergum 2 about 0.25 mm. in width; color light green with purple or pink iridescence.

Female. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is broadened distally. (22) Clypeal margin slightly emarginate in center. (23) Head and thorax with coarse punctures; mesoscutum with spaces between punctures smooth or minutely roughened. (24) Metepisternum with many fine to fewer coarse wrinkles. (25) Tergum 1 with close, coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band two-fifths width of depressed area to absent in center and reduced to two rows at sides; center of tergum not highly polished. (26) Tergum 2 with punctures same size as those of center of tergum 1; tergum 2 not highly polished; postgradular area not depressed below level of pregradular area. (27) Terga 3 and 4 with coarse punctures like those of center of tergum 2 except punctures toward base of tergum 4 smaller than on rest of tergum. *Pubescence:* (28) Body hairs white with some black hairs on terga 4 to 6, black hairs may be absent on tergum 4. *Color:* (29) Antenna orange to red-brown below, black to red-brown above. (30) Stigma darkened or light in color like most wing veins. (31) Colored band of tergum 2 about 0.33 mm. in width; color yellow or light green with pink, red or purple iridescence.

Type Material. The male holotype of *universitatis,* Boulder, Colorado, July 14, 1908 (Paul M. Dean), is in the U. S. National Museum, type number 55859. A male paratype, Boulder, Colorado, July 6, 1908 (T. D. A. Cockerell), was not located.

Range. *N. universitatis* ranges from North Dakota to Texas between the Rocky Mountains and the Mississippi River (map 1).

List of Localities. Colorado. Baca Co.: Two Buttes ♀ ♂; Bent Co.: Prowers (N. of) 2 ♀; Boulder Co. 3 ♀: Boulder 3 ♀ 3 ♂, (2 mi. N.) ♂, (Boulder Canyon) 2 ♀; Denver Co.: Denver ♀ ♂; El Paso Co.: Colorado Springs ♂; Huerfano Co.: La Veta ♀; Jefferson Co.: Golden 2 ♂; Larimer Co.: Fort Collins 3 ♀ 4 ♂; Logan Co.: Peetz 2 ♂; Iowa. Lyon Co.: Little Rock 2 ♂. Kansas. Bourbon Co.: Fort Scott 3 ♀ 3 ♂; Clark Co.: State Park ♂; Douglas Co.: Baldwin City ♀, Lawrence ♂; Ellis Co. 2 ♀; Geary Co. 2 ♀; Graham Co. ♀; Gray Co. ♀; Jewell Co. ♂; Marshall Co. 2 ♀: Marysville 2 ♂; Morton Co. ♀; Riley Co. ♀ 6 ♂: Manhattan ♀; Scott Co.: Scott City ♂; Sheridan Co. ♀ ♂; Stanton Co. ♀. Ne-

BRASKA. Adams Co.: Hastings ♀ ♂; Cherry Co.: Valentine (Fort Niobrara) ♂; Cuming Co.: West Point ♂; Custer Co.: Broken Bow ♀; Dixon Co.: Maskell ♀; Douglas Co.: Omaha ♀ ♂; Dundy Co. ♀; Fillmore Co.: Fairmont 4♂; Lancaster Co.: Lincoln 7♀ 2♂; Scotts Bluff Co.: Mitchell ♀ ♂. NEW MEXICO. Bernalillo Co.: Sandia Mountains ♀. NORTH DAKOTA. Slope Co.: Marmarth.* SOUTH DAKOTA. Brookings Co.: Brookings ♂; Custer Co.: Pringle ♂; Davison Co.: Mitchell ♀; Grant Co.: Big Stone City;* Fall River Co.: Hot Springs 3 ♂. TEXAS. Brazos Co. ♀; Deaf Smith Co.: Hereford (5 mi. S. W.) 3♀.

FLOWER RECORDS. COMPOSITAE: Coneflower ♀. LEGUMINOSAE: *Amorpha canescens* ♀, *Astragalus gracilis,** *Dalea* sp. ♂, *Medicago sativa* 4♀, *Melilotus alba* 5♀ 2♂, *M. officinalis* ♀ ♂, *Petalostemum* sp. 2♀, *P. purpureum,** *Psoralea* sp. 3♀, *P. tenuiflora* ♀ ♂.

PREDATORS. Cockerell (1908) found the paratype of this species struggling with a worker of *Pogonomyrmex occidentalis* (Hymenoptera: Formicidae).

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults.

Nomia (*Curvinomia*) *angustitibialis*, new species

(Figs 4, 15 and 21; Map 3; Table 5)

This species can be differentiated from other North American *Curvinomia* by the coarse punctation, wide, yellow abdominal bands, and in the male by the almost unmodified hind tibia.

MALE. *Structure:* (1) Clypeal margin produced into a median tooth; submarginal area punctate except for tooth; clypeus with longitudinal, impunctate line. (2) Metepisternum with many fine wrinkles. (3) Propodeum with coarse punctures on posterior face. (4) First m-cu several vein widths basal from first r-m. (5) Posterior femur three times as long as broad. (6) Posterior tibia not greatly expanded toward apex (fig. 4). (7) Tergum 1 with coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; band two rows of punctures wide, absent toward center. (8) Tergum 2 with punctures like those of center of tergum 1; groove between postgradular and pregradular areas deep, its anterior face vertical, posterior face sloping gently upward. (9) Terga 3 and 4 much more finely punctate than center of tergum 1, except raised area of tergum 3 which has punctures like those of tergum 1. (10) Sternum 5 with lateral, longer part of median, apical process about as long as wide and rounded at

apex, processes widely separated; lateroapical hairy pads with hairs considerably short of meeting along midline, hairs in center of pad not darkened, pads half round in shape; median basal emargination almost three times as wide as deep, V-shaped (fig. 15). (11) Gonocoxite with apex of dorsal recurved part not bent outward and emarginate. (12) Gonostylus with plate at its base with small bumps on inner side. (13) Exposed part of penis valve little more than half as wide as long, tip narrow and pointed, inner subapical margin rounded, extreme lateral part with rounded lobe, anteroventral process J-shaped (fig. 21). *Pubescence:* (14) Terga 4 to 7 with some black hairs, sometimes absent on tergum 4; tergum 3 with hairs all white. (15) Gonocoxite with dorsal recurved part with medium sized, slender hairs at tip arising from inner margin. *Color:* (16) Mandible translucent orange to black with red tip and red-brown base. (17) Antenna orange to red-brown below, black above. (18) Legs black to red-brown. (19) Stigma light in color like most wing veins. (20) Colored band of tergum 2 about 0.50 mm. in width; color yellow, white or green with pink, green, gold or yellow iridescence.

Female. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is broadened distally. (22) Clypeal margin emarginate in center. (23) Head and thorax with coarse punctures; mesoscutum with spaces between punctures minutely roughened. (24) Metepisternum with many fine wrinkles. (25) Tergum 1 with close, coarse punctures except sometimes for band of smaller punctures at base of apical, depressed, hyaline portion; band absent medially to complete and one-third width of depressed area; center of tergum not highly polished. (26) Tergum 2 with punctures same size as those of center of tergum 1 or smaller; tergum 2 not highly polished; postgradular area not depressed below level of pregradular area. (27) Terga 3 and 4 with small punctures, much smaller than those of tergum 2. *Pubescence:* (28) Body hairs white with some black hairs on terga 4 to 6, may be absent on tergum 4. *Color:* (29) Antenna red-brown below, black above. (30) Stigma darkened or light in color like most wing veins. (31) Colored band on tergum 2 about 0.50 mm. in width; color yellow or green with purple or red iridescence.

Variation. Little variation has been noted in the characters studied in the few specimens of this species examined. A male and a female from Taxco (23 mi. N.), Mexico, are slightly smaller in size, have narrower abdominal bands and slightly less punctate

thorax and abdomen. A male from Cuernavaca (46 mi. S.), Mexico, is intermediate between the Taxco male and the typical *angustitibialis* in these characters. On the basis of other characters these Mexican specimens seem to belong to this species, and the other Mexican specimens agree with those from Arizona.

TYPE MATERIAL. HOLOTYPE: ♂, Southwestern Research Station (5 mi. W. Portal), Cochise Co., Arizona, August 21, 1956 (C. & M. Cazier), 5,400 ft. elev., on *Melilotus alba*. ALLOTYPE: ♀, same label data as holotype except collected on August 3 by E. Ordway. The holotype and allotype are in the collection of the American Museum of Natural History. PARATYPES: 17 ♂ and 34 ♀ from Arizona and 1 ♂ from Mexico. ARIZONA. Cochise Co.: Huachua Mountains, no date, U. S. Nat. Mus., 2 ♀; Huachua Mountains, September 27, 1936 (R. H. Crandall), Univ. Ariz., ♀; Carr Canyon, Huachua Mountains, August 6, 1924 (F. P. Van Duzee), Calif. Acad. Sci., ♂; Ramsey Canyon, Huachua Mountains, September 5, 1955 (F. G. Werner & G. D. Butler), Univ. Ariz., ♀ ♂; 2 mi. W. Portal, September 14, 1955 (G. E. Bohart), Utah State Univ., ♀; Portal, August 12, 1944 (W. W. Jones), Univ. Calif., Riverside, ♀ 6 ♂; 5 mi. W. Portal, August 21, 1956 (C. & M. Cazier), 5,400 ft. elev., on *Melilotus alba*, Univ. Kansas, ♂; 5 mi. W. Portal, August 12, 1956 (E. Ordway), 5,400 ft. elev., on *Melilotus alba*, Amer. Mus. Nat. Hist., ♂; 5 mi. W. Portal, August 1, 1956 (C. & M. Cazier), 5,400 ft. elev., on *Melilotus alba*, Amer. Mus. Nat. Hist., 3 ♂; 5 mi. W. Portal, August 2, 1956 (E. Ordway), 5,400 ft. elev., on *Melilotus alba*, Amer. Mus. Nat. Hist., ♂; Graham Co.: Graham Mountains, August 18, 1954 (R. M. Bohart), 3,500-4,500 ft. elev., Univ. Calif., Davis, ♀; Graham Mountains, August 15, 1953 (G. D. Butler), 5,000-6,000 ft. elev., Univ. Ariz., ♀; Pima Co.: Molino Basin, Santa Catalina Mountains, August 15, 1954 (R. M. Bohart), 5,000 ft. elev., Univ. Calif., Davis, 3 ♀; Molino Basin, Santa Catalina Mountains, September 8, 1951 (C. D. MacNeill), Univ. Calif., Berkeley, ♀; Molino Basin, Santa Catalina Mountains, August 29, 1951 (C. D. MacNeill), Univ. Calif., Berkeley, ♀; Molino Basin, Santa Catalina Mountains, September 7, 1951 (C. D. MacNeill), Univ. Calif., Berkeley, 2 ♀; Molino Basin, Santa Catalina Mountains, September 9, 1951 (C. D. MacNeill), Univ. Calif., Berkeley, ♀; Santa Cruz Co.: 2.5 mi. W. Peña Blanca Lake, August 17, 1961 (J. C. Bequeart), Univ. Ariz., 2 ♂; 5.5 mi. W. Peña Blanca Lake, August 17, 1961 (Werner & Bequaert), Univ. Ariz., ♀; Sycamore Canyon, near Ruby, August 16-17, 1961 (Werner & Bequaert),

Univ. Ariz., ♀; Madera Canyon, Santa Rita Mountains, August 9, 1947 (L. Martin), on yellow composite, Los Angeles Co. Mus., 5 ♀; Madera Canyon, Santa Rita Mountains, August 20, 1952 (L. M. Martin), Los Angeles Co. Mus., ♂; Madera Canyon, Santa Rita Mountains, August 2-4, 1959 (K. V. Krombein), U. S. Nat. Mus., 2 ♀; foot of Miller Creek?, Santa Rita Mountains, August 16, 1940 (E. C. Van Dyke), Calif. Acad. Sci., 8 ♀; foot of Miller Creek?, Santa Rita Mountains, August 16, 1940 (E. C. Van Dyke), Univ. Kansas, ♀. México. Sonora: 6 mi. N. W. Cananea, August 15, 1959 (W. L. Nutting & F. G. Werner), 6,000 ft. elev., Univ. Ariz., ♂.

The Mexican specimens not included in the type series are as follows: Durango: Canutillo (8 mi. S.) ♀, Coyotes (4 mi. S. W. El Salto) 2 ♀, El Salto (6 mi. N. E.) 2 ♀; Guerrero: Taxco (23 mi. N.) ♀ ♂; Morelos: Cuernavaca (46 mi. S.) ♂.

Range. This species ranges from southeastern Arizona to the state of Guerrero in Mexico (map 3). It has not been found in tropical Mexico.

Flower Records. See under Type Material.

Seasonal Activity. See under Type Material. Table 5 gives a summary of the seasonal activity of the adults.

Nomia (*Curvinomia*) *foxii* Dalla Torre

(Figs. 5, 16 and 22; Map 2; Tables 1 and 5)

Nomia punctata Fox, 1893, p. 134 (not Smith, 1875) (tax., ♀); Cockerell, 1896, p. 34 (fls.).

Nomia foxii Dalla Torre, 1896, p. 167 (new name for *N. punctata* Fox) (in part) (cat.); Cockerell, 1897, p. 20 (rec.); Cockerell, 1898b, p. 50 (in part) (tax.); Cockerell, 1898c, p. 50 (in part) (tax.); Cockerell, 1898d, p. 31 (in part) (tax., ♂); Cockerell, 1902, p. 812 (fls.); Cockerell, 1906a, p. 298 (in part) (rec.); Cockerell, 1906b, p. 279 (tax.); Viereck, 1906, p. 237 (rec.); Cockerell, 1907, p. 242 (tax.); Snow, 1907, p. 136 (in part) (rec.); Cockerell, 1908, p. 333 (only ♂) (tax. ♂); Cockerell, 1910a, p. 277 (only ♂) (tax.); Michener, 1936, p. 4 (tax.).

Nomia (*Paranomia*) *foxii:* Cockerell, 1905, p. 322 (tax.); Cockerell, 1910b, p. 290 (tax.).

Nomia mesillensis Cockerell, 1908, p. 334 (tax., ♀); Cockerell, 1910a, p. 277 (tax.); Cockerell, 1912, p. 493 (tax.); Cockerell, 1930, p. 13 (tax.); Cockerell, 1934b, p. 7 (tax.), new synonymy.

Nomia (*Paranomia*) *mesillensis:* Cockerell, 1910b, p. 297 (tax.).

Nomia (*Acunomia*) *foxii:* Michener, 1951, p. 1127 (in part) (cat.).

Nomia (*Acunomia*) *mesillensis:* Michener, 1951, p. 1128 (cat.).

Nomia (*Paranomina*) *mesillensis:* Cross, 1958a, p. 1266 (tax.).

Nomia (*Paranomina*) *foxii:* Cross, 1958a, p. 1266 (tax.).

Nomia tetrazonata: Evans & Linsley, 1960, pp. 32 and 35 (para.); Linsley, 1960, pp. 362, 366 and 374 (para.) (misidentifications).

There has been a great deal of confusion concerning the status of this species, due in part to no one's having examined the syntypes of *punctata* (= *foxii*), and to the original description of *punctata,* which states the abdomen is "distinctly, sometimes coarsely punctured." *N. foxii* is the least punctate North American banded *Nomia.* The original description also states that the abdomen is "shining." *N. foxii* is the only *Curvinomia* with a shining abdomen. *N. punctata* was described from three female specimens from the following localities: Denver, Colorado; Vega San Jose, New Mexico; and Big Stone City, South Dakota. Only the specimen from New Mexico has been located and is what has been called *mesillensis* (= *foxii*). This form is not known to occur as far north as Denver. The two missing syntypes must be *universitatis* (for further details see discussion of *universitatis*). The specimen from New Mexico most closely agrees with the description of *punctata,* while *universitatis* most closely agrees with Fox's (1893) var. (?). Cockerell (1906a) selected Denver as the type locality for *foxii.* This is an incorrect designation of the type locality, because the Denver specimen probably was an *universitatis,* which is Fox's "variety." Cockerell later (1908) correctly selected the "New Mexico species as the true *foxii*" (!) (*universitatis* also occurs in New Mexico, but this was not known to him).

Females that Cockerell identified as *foxii* prior to 1912 belong to the species now known as *tetrazonata,* and males he then assigned to *foxii* were actually that species. However, upon finding associated males and females of *foxii* in 1912, he abandoned this earlier identification, assigning the males and associated females to his (1908) species *mesillensis.* For the females earlier called *foxii,* he continued to use that name, stating (Cockerell, 1912) that he believed Crawford's (1911) *moctezumae* to be a synonym of *foxii. N. moctezumae* is now, however, known to be a synonym of *tetrazonata.*

The female of *foxii* can be differentiated from other North American *Curvinomia* by the shining metasoma, and the male can be differentiated by the shape of the hind tibia and lateroapical hairy pads on sternum 5.

Male. *Structure:* (1) Clypeal margin broadly rounded in center with wide submarginal impunctate area; clypeus with weak longitudinal ridge. (2) Metepisternum with many fine to a few coarse wrinkles. (3) Propodeum with medium-sized punctures on posterior face. (4) First m-cu several vein width basal from first r-m. (5) Posterior femur twice as long as broad. (6) Posterior tibia greatly expanded toward apex (fig. 5). (7) Tergum 1 with coarse punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band two-thirds width of depressed area to reduced to a few scattered punctures. (8) Tergum 2 with punctures smaller than in center of tergum 1; groove between postgradular and pregradular areas deep, its anterior face vertical, posterior face sloping gently upward. (9) Terga 3 and 4 much more finely punctate than in center of tergum 1. (10) Sternum 5 with lateral, longer part of median, apical process about twice as long as wide and rounded at apex, processes widely separated; lateroapical hairy pads with hairs considerably overlapping along midline, hairs in center of pad not darkened, pads crescent-shaped; median basal emargination about twice as wide as deep, V-shaped (fig. 16). (11) Gonocoxite with dorsal recurved part bent outward and irregularly rounded. (12) Gonostylus with plate at its base with small bumps on inner side. (13) Exposed part of penis valve two-thirds as wide as long, tip broad and pointed, inner subapical margin with large rounded lobe, extreme lateral part with anteriorly pointing tooth, anteroventral process considerably bent (fig. 22). *Pubescence:* (14) Terga 4 to 7 with some black hairs, sometimes absent on tergum 4; tergum 3 with hairs all white. (15) Gonocoxite with dorsal recurved part with large, stout hairs at tip arising near inner margin. *Color:* (16) Mandible black with red tip. (17) Antenna orange to brown below, black above. (18) Legs black to red-brown with basitarsus and apex of hind tibia yellow. (19) Stigma darkened or light in color like most wing veins. (20) Colored band of tergum 2 about 0.50 mm. in width; color green with gold, red, purple, white or yellow iridescence.

Female. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is not broadened distally. (22) Clypeal margin truncate to slightly emarginate in center. (23) Head and thorax with medium-sized punctures; mesoscutum with spaces between punctures smooth. (24) Metepisternum with many fine to fewer coarse wrinkles. (25) Tergum 1 with scattered fine punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-half to two-fifths width of depressed area; center of tergum highly polished. (26) Tergum 2 with punctures coarser than in center of tergum 1; highest part of tergum 2 nearly impunctate and highly polished; postgradular area not depressed below level of pregradular area. (27) Terga 3 and 4 with small punctures, much smaller than those of tergum 2. *Pubescence:* (28) Body hairs white with some black hairs on terga 3 to 6. *Color:* (29) Antenna orange to brown below, black to red-brown above. (30) Stigma darkened or light in color like most wing veins. (31) Colored band of tergum 2 about 0.50 mm. in width; color green with red-orange, purple or cream iridescence.

Type Material. *N. punctata* (= *foxii*) was described from three females. One of these, from Vega San Jose, New Mexico, August 4 (C. H. Tyler Townsend), is at the Academy of Natural Sciences of Philadelphia. Vega San Jose could not be located on any map, but it is thought to refer to La Vega (a plain around San Rafael) south of the Rio San Jose in northern Valencia County. The other syntypes (Denver, Colorado, E. V. Beales and Big Stone City, South Dakota, J. F. Aldrich) could not be located, but are thought to be *universitatis* (see above and under *universitatis*). Cockerell (1908) did not specifically designate the New Mexico specimen as the lectotype, but that was clearly his intent. I therefore here designate the female from Vega San Jose, New Mexico, as the lectotype of *N. foxii.* The female holotype of *N. mesillensis,* Mesilla Valley ("towards Organ Mountains"), New Mexico, end of September (T. D. A. Cockerell), is in the U. S. National Museum, type number 55860.

Range. This species ranges from southern Colorado westward to Arizona and southward to Jalisco, Mexico (map 2). It does not occur in tropical Mexico.

List of Localities. Arizona. Apache Co.: White Mountains 2 ♀ 5 ♂; Cochise Co.: Apache ♂, (5 mi. S. E.) ♀, (4 mi. S. W.) ♀, Chiricahua National Monument 2 ♂, Dos Cabezas (16 mi. S. E.)

♀, Douglas 4♂, (8 mi. N.) 22♂, (18 mi. N.) ♀2♂, (20 mi. N.) 8♂, (21 mi. N.) ♂, (30 mi. N.) 6♂, (45 mi. N.) 13♀15♂, El Frida ♂, Fairbank (7 mi. W.) 2♀3♂, Huachuca Mountains (Ramsey Canyon) 3♀, (6 mi. W. Montezuma Pass) ♂, Pearce 5♂, (6 mi. N.) ♀4♂, Portal 12♂, (2 mi. N. E.) 3♀21♂, (2.5 mi. N. E.) ♀2♂, (5 mi. W.) 14♀ 29♂, Rodeo, New Mexico (6 mi. W.) ♀, Sands Ranch (Dry Canyon, S. E. end Whetstone Mountains) ♀, Skeleton Canyon (6 mi. S. E. Apache) ♀♂, Turner (7 mi. N. W. Fort Huachuca) ♂, Willcox 3♂; Coconino Co.: Flagstaff ♀, (15 mi N.) 4♂, (15-20 mi. N.) 4♀, (20 mi. N.) 6♀2♂, (25 mi. N.) 12♀ 2♂, Mormon Lake 2♀, Oak Creek Canyon 17♀2♂, Turkey Tanks (near Cosnino) ♀; Gila Co.: Cedar Creek (15 mi. W. Fort Apache) ♂, Young 2♂; Navajo Co.: Forestdale Trading Post (9 mi. S. W. Show Low) ♂, Marsh Pass (12 mi. S. W. Kayenta) ♀, Shumway 5♀; Santa Cruz Co.: Canelo 6♂, Locheil (9 mi. E.) 7♀, Mustang Mountains ♂, Patagonia 3♀8♂, Sonoita (10 mi. E.) 10♀2♂, Sycamore Canyon (4 mi. S. E. Ruby) 3♀♂; Yavapai Co.: Dewey 29 ♀, Lonesome Valley (10 mi. N. E. Prescott) ♀, Mt. Mingus (6 mi. S. W.) 10♂, Prescott 38♀202♂, (6 mi. N. W.) ♂, (10 mi. N.) ♂, (23 mi. N. W.) ♂. CALIFORNIA. San Bernardino Co.: Needles ♀. COLORADO. Las Animas Co.: Hoehne (N. E.) ♀; Montezuma Co.: Yellow Jacket 45♀♂. NEW MEXICO. Bernalillo Co.: Sandia Mountains 2♂; Catron Co.: Alma 4♂, (5 mi. N.) 4♀, Whitewater Canyon (4 mi. N. E. Glenwood) ♀; Chaves Co.: East Grand Plains (7 mi. S. E. Roswell) ♀, Roswell 21♀11♂, (5 mi. S.) ♀; Colfax Co.: Koehler 2♀; Dona Ana Co.: Mesilla Valley (towards Organ Mountains) ♀; Eddy Co.: Hope 2♀; Hidalgo Co.: Lordsburg (13 mi. N. W.) ♀♂, (15 mi. E.) ♂, (25 mi. E.) 4♂, Rodeo 10♀79♂, (1 mi. S.) ♀♂, (1 mi. W.) 2♂, (1.5 mi. S.) 6♀34♂, (2 mi. N.) ♀7♂, (4.8 mi. N.) ♀, (7 mi. S. E.) ♂; Luna Co.: Deming ♀4♂, (14 mi. W.) ♂; Otero Co.: Mountain Park ♀9♂; Rio Arriba Co.: El Rito ♂; Roosevelt Co.: Portales 4♂; San Juan Co.: Farmington ♂; San Miguel Co.: Los Montoyas 19♀♂, Pecos River (Pecos) 2♂, Sapello ♀, San Jose ♂; Santa Fé Co.: Santa Fé 5♀3♂; Taos Co.: Embudo (6 mi. N. E.) 4♀; Valencia Co.: Cubero 3♀♂, Vega San Jose (near San Rafael) ♀♂. TEXAS. Brewster Co.: Alpine 2♀♂; Culberson Co.: ♀; Jeff Davis Co.: Fort Davis (10 mi. S.) ♀3♂, (21 mi. W.) ♂. MÉXICO. Aguascalientes: Aguascalientes (40 mi. N.) ♀2♂, Rincón de Romos (12 km. N.) ♀9♂; Chihuahua: Ciudad Camargo (20 mi. S. W.) ♂, Catarinas (22 mi. S. E. Hidalgo

del Parral) 3♂, Chihuahua (30 mi. N. W.) 6♂, (45 mi. N. W.) ♀, Gallego (8 mi. S.) 4♂, Hidalgo de Parral (29 mi. E.) 16♀8♂, (42 mi. S.) ♀, (66 mi. S.) 4♀19♂, Jiménez (18 mi. W.) 7♀16♂, (78 mi. W.) ♀18♂, Moctezuma 2♀, Santa Barbara 2♀4♂, (36 km. S.) ♂, Salaíces ♀; Coahuila: La Rosa ♂, Paila (80 mi. E. Torreón) ♂, Saltillo (5 mi. N.) ♀; Durango: Canutillo (8 mi. S.) 9♀19♂, Durango ♂, (14 mi. N. E.) ♂, (20 mi. N.) 5♀3♂, (23 mi. N. E.) 2♀7♂, (50 mi. S.) ♀ ♂, (156 mi. N.) 2♂, Encino (15 mi. N. Santa María del Oro) ♀, Nombre de Dios 14♀11♂, (16 mi. S.) 6♂, San Juan del Rio ♀3♂, Torreón ♀3♂, Yerbanís ♀ ♂; Jalisco: Encarnacion de Díaz 8♂, Lagos de Moreno (15 mi. N. E.) ♀, San Juan de los Lagos ♀4♂, (8 mi. S. W.) ♀; Sonora: Agua Prieta ♂; Zacatecas: Fresnillo (8 mi. S.) ♂, (9 mi. S.) 10♀9♂, Zacatecas (34 mi. S.) 2♀.

TABLE 1.—Summary of Flower Records for *Nomia foxii* Dalla Torre

Plant Data*			Records of *N. foxii*			
FAMILY	Number of genera	Number of species	Number of collections	Number of females	Number of males	Total number of bees
Asclepiadaceae	1	2	16	23	139	162
Capparidaceae	1	2	9	22	9	31
Compositae	6	6	15	16	55	71
Cruciferae	1	1	2	2	9	11
Euphorbiaceae	1	1	1	0	1	1
Leguminosae	7	8	41	112	237	349
Liliaceae	1	1	1	1	0	1
Loasaceae	2	2	2	0	2	2
Malvaceae	1	1	1	0	1	1
Polygonaceae	1	1	4	9	2	11
Rubiaceae	1	1	1	0	2	2
Solanaceae	1	2	1	1	0	1
Verbenaceae	1	1	1	1	0	1
Zygophyllaceae	1	1	6	4	8	12
Total	26	30	101	191	465	656

* Records from the literature are included under this heading.

FLOWER RECORDS. ASCLEPIADACEA: *Asclepias* sp. 11♀91♂, *A. Linaria* 8♀6♂, *A. subverticillata* 4♀43♂. CAPPARIDACEAE: *Cleome* sp. 16♀3♂, *C. Jonesii* 2♀6♂, *C. serrulata* 4♀. COMPOSITAE: *Baccharis* sp. 10♀38♂, *B. glutinosa* 7♂, *Cirsium* sp. ♀, *Guardiola Tulocarpus* 4♀7♂, *Gutierrezia sarothrae* ♀, *Haplopappus* sp. ♀, *Helianthus annuus* 2♂, *Verbesina* sp. ♂. CRUCIFERAE: *Lepidium* sp. 2♀9♂. EUPHORBIACEAE: *Croton* sp. ♂. LEGUMINOSAE: *Crotalaria*

pumila ♀, *Eysenhardtia polystachya* 10 ♀ 7 ♂, *Lotus Wrightii* 31 ♀ 196 ♂, *Medicago sativa* 28 ♀, *Melilotus* sp. 4 ♀, *M. alba* 31 ♀ 25 ♂, *M. officinalis* ♀ 4 ♂, *Petalostemum* sp. ♀ ♂, *P. candidum* 5 ♀, *Psoralea teniflora* ♂. Lilaceae: *Nolina* sp. ♀. Loasaceae: *Cerallia sinuata* ♂, *Mentzelia pumila* ♂. Malvaceae: *Gossypium* ♂. Polygonaceae: *Eriogonum* sp. 8 ♀ ♂, *E. Abertianum* ♀ ♂. Rubiaceae: *Crusea subulata* 2 ♂. Solanaceae: *Solanum elaeagnifolium,** *S. rostratum* ♀. Verbenaceae: *Aloysia Wrightii* ♀. Zygophyllaceae: *Larrea tridentata* 4 ♀ 8 ♂.

The above flower records are summarized in table 1.

Parasites and Predators. Mr. R. C. Funk identified mites from the fourth and fifth abdominal terga of a male from Douglas (8 mi. N.), Arizona, as *Glyphanoetus* sp. (Acarina: Anoetidae). *Mallophora bromleyi* and *Blepharepium secabilis* (Diptera: Asilidae) prey upon *N. foxii* (Linsley, 1960), listed as *N. tetrazonata.*

Seasonal Activity. Table 5 gives the seasonal activity of the adults.

Nomia (*Curvinomia*) *tetrazonata* Cockerell

This species can be distinguished from other North American *Curvinomia* by the narrow abdominal bands, medium- to small-sized punctures, in the female by the nonpolished metasomal terga, and in the males by the campaniform lateroapical hairy pads on sternum 5 with darkened hairs in the centers.

Male. *Structure:* (1) Clypeal margin broadly rounded in center with narrow submarginal impunctate area; clypeus with weak longitudinal carina. (2) Metepisternum with many fine wrinkles to wrinkles absent. (3) Propodeum with fine punctures on posterior face. (4) First m-cu several vein widths basal from first r-m. (5) Posterior femur twice as long as broad. (6) Posterior tibia greatly expanded toward apex (fig. 6). (7) Tergum 1 with medium-sized punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-third width of depressed area. (8) Tergum 2 with punctures like those of center of tergum 1; groove between postgradular and pregradular area deep, its anterior face nearly vertical, posterior face sloping gently upward or groove shallow and U-shaped. (9) Terga 3 and 4 more finely punctate than center of tergum 1, except that raised area of tergum 3 which has punctures like those of tergum 1. (10) Sternum 5 with lateral, longer part of median, apical process three times as long as wide and truncate at apex, processes widely separated; lateroapical hairy pads with hairs considerably short

of meeting along midline, hairs in center of pad much darker, pads campaniform; median, basal emargination about twice as wide as deep, V-shaped (fig. 17). (11) Gonocoxite with dorsal recurved part bent outward and rounded. (12) Gonostylus with plate at its base papillose on inner side. (13) Exposed part of penis valve two-thirds as wide as long, tip broad and pointed, inner subapical margin with elongate lobe, extreme lateral part with anteriorly pointing tooth, anteroventral process slightly bent (fig. 23). *Pubescence:* (14) Terga 5 to 7 with some black hairs; terga 3 and 4 with hairs all white. (15) Gonocoxite with dorsal recurved part with large, long, slender hairs at tip arising from well behind inner margin. *Color:* (16) Mandible orange to black with red tip. (17) Antenna orange to brown below, black to red-brown above. (18) Legs black to red-brown with basal part of hind basitarsus and hind tibial lobe yellow. (19) Stigma darkened or light in color like most wing veins. (20) Colored band on tergum 2 about 0.33 mm. in width; color green with purple, gold or pink iridescence.

FEMALE. *Structure:* (21) Labrum with median longitudinal ridge, upper margin of which is not broadened distally. (22) Clypeal margin emarginate in center. (23) Head and thorax with fine punctures; mesoscutum with spaces between punctures smooth to minutely roughened. (24) Metepisternum with many fine wrinkles. (25) Tergum 1 with close, fine to minute scattered punctures except for band of smaller punctures at base of apical, depressed, hyaline portion; median width of band one-half to two-fifths width of depressed area; center of tergum not highly polished. (26) Tergum 2 with punctures like those of center of tergum 1 or smaller, apical higher portion sometimes nearly impunctate; tergum 2 not highly polished; postgradular area not depressed below level of pregradular area. (27) Terga 3 and 4 with fine to minute punctures like those of tergum 2 or finer. *Pubescence:* (28) Body hairs white with some black hairs on terga 4 to 6, may be absent on tergum 4. *Color:* (29) Antenna orange to red-brown below, black to red-brown above. (30) Stigma darkened or light in color like most wing veins. (31) Colored band on tergum 2 about 0.33 mm. in width; color green with red, red-orange, purple or pink iridescence.

Nomia (*Curvinomia*) *tetrazonata tetrazonata* Cockerell

(Figs. 17 and 23; Map 1; Tables 2 and 5)

Nomia foxii: Cockerell, 1898a, p. 311 (fls.); Cockerell 1898b, p.

50 (in part) (tax.); Cockerell, 1898c, p. 50 (in part) (tax.); Cockerell, 1906a, p. 298 (in part) (rec.); Snow, 1907, p. 136 (in part) (rec.); Cockerell, 1908, p. 334 (only ♀) (tax., ♀); Cockerell, 1910a, p. 276 (only ♀) (tax.); Cockerell, 1912, p. 493 (tax.); Cockerell, 1930, p. 13 (tax.) (misidentifications).

Nomia (*Paranomia*) *tetrazonata* Cockerell, 1910b, p. 297 (tax., ♂).

Nomia moctezumae Crawford, 1911, p. 618 (tax., ♀); Cockerell, 1912, p. 493 (tax.); Cockerell, 1923, p. 103 (rec.); Cockerell, 1930, p. 13 (tax.).

Nomia tetrazonata: Cockerell, 1930, p. 13 (tax.); Michener, 1936, p. 4 (tax.); Michener, 1937, p. 319 (rec.); Linsley, 1962, p. 79 (fls.).

Nomia californiensis Michener, 1937, p. 318 (tax., ♀), new synonymy.

Nomia (*Curvinomia*) *californiensis:* Michener, 1944, p. 251 (tax.); Michener, 1951, p. 1127 (cat.).

Nomia (*Acunomia*) *foxii:* Michener, 1951, p. 1127 (in part) (cat.) (misidentification).

Nomia (*Acunomia*) *tetrazonata:* Michener, 1951, p. 1128 (cat.).

Nomia (*Paranomina*) *californiensis:* Cross, 1958a, p. 1266 (tax.).

Nomia (*Paranomina*) *tetrazonata:* Cross, 1958a, p. 1266 (tax.).

Cockerell was misled by Fox's description of *punctata* (= *foxii*), and considered the female *t. tetrazonata* as *foxii* (see discussion under *foxii* for further details). *N. californiensis* is a *t. tetrazonata* that has lost the bright color of the abdominal bands; such loss occurs when a specimen becomes wet.

N. t. tetrazonata can be separated from *t. uvaldensis* by the characters given below.

Male. (8). Tergum 2 with groove anterior to center, punctate part of postgradular area about three times as wide as colored band; groove deep, anterior face vertical, posterior face sloping gently upward; depressed area strongly and abruptly depressed, not much wider than colored band; terga 2 to 4 with punctures deep and sharp.

Female. (25) Tergum 1 with close, fine punctures not much finer than those of mesoscutum. (26) Tergum 2 with punctures like those of tergum 1, apical, higher portion with many punctures. (27) Terga 3 and 4 with fine, close punctures like those of tergum 1 or finer.

VARIATION. Little variation has been noted in the characters studied even though a large number of specimens of this subspecies were examined. The few characters that separate *t. tetrazonata* from *t. uvaldensis* are constant, and no intergrades have been found, but few specimens have been examined from the area where the ranges of these subspecies meet.

TYPE MATERIAL. The male holotype of *N. tetrazonata*, Globe, Arizona, July 25, 1892 (W. H. Ashmead collection), is in the U. S. National Museum, type number 12988. There were two male paratypes with these label data; one of these is in the U. S. National Museum. Another male paratype in the same museum is from the Bradshaw Mountains, Arizona, June 21, 1892 (W. H. Ashmead collection). The female holotype of *californiensis*, Cushinbury Springs (north side San Bernardino Mountains), California, August 19, 1933 (C. D. Michener), is at the University of Kansas, type number 5933. The female holotype of *moctezumae*, Guaymas, Sonora, Mexico (L. O. Howard), is in the U. S. National Museum, type number 13456.

RANGE. This subspecies ranges from Nevada and southeastern California to central New Mexico and southward to Sonora and Baja California (map 1).

LIST OF LOCALITIES. ARIZONA. Apache Co.: Chinle ♂; Cochise Co.: Benson 7 ♀ 20 ♂, (5 mi. W.) 5 ♂, Douglas (8 mi. E.) ♂, (17 mi. E.) 2 ♂, Fort Huachuca (11 mi. N. W.) 2 ♀, Kansas Settlement 2 ♀, Portal ♀ 2 ♂, (2 mi. N. E.) ♀ 3 ♂, (2.5 mi. N. E.) ♀, (5 mi. E.) 10 ♀ 13 ♂, (10 mi. E.) ♂, (15 mi. W.) 2 ♀, San Bernardino Ranch (15 mi. E. Douglas) ♂, Sands Ranch (Dry Canyon, S. E. end Whetstone Mountains) ♀, Texas Pass ♂, Tombstone ♀ 2 ♂, (12 mi. W.) 3 ♂, Willcox (4.2 mi. W.) ♀ ♂; Coconino Co.: Oak Creek Canyon ♀ ♂, Sedona ♀ ♂, Walnut (= Winona) 2 ♂; Gila Co.: Claypool (5 mi. W. Globe) ♂, Gila River Canyon (near Christmas) 4 ♂, Globe 2 ♀ 5 ♂, (12 mi. N.) ♀, Roosevelt 17 ♂; Graham Co.: Aravaipa Creek ♀, Fort Thomas 3 ♂, Geronimo (9 mi. N. W.) ♀, Graham Mountains (15 mi. N. Wilcox) ♀, Roosevelt Lake (E. end) 13 ♀, Safford ♀; Maricopa Co.: Cavecreek ♀ ♂, Chandler ♀, Gila Bend (25 mi. E) ♀, Glendale ♀, Granite Reef Dam (10 mi. N. E. Mesa) ♂, Mesa ♀, (25 mi. E.) ♂, Phoenix 5 ♀, Tempe ♂, Wickenberg ♂; Pina Co.: Arivaca ♂, Baboquivari Canyon 5 ♀, Brown's Canyon (Baboquivari Mountains) 3 ♂, Continental ♀, Elkhorn Ranch (N. E. end Baboquivari Mountains) ♂, Mount Lemmon Road (Santa Catalina Mountains) 3 ♀, Organ

Pipe Cactus National Monument 2♀, Ouijotoa (30 mi. E) ♀, Sabino Canyon (Santa Catalina Mountains) 13♀2♂, Sahuarita ♂, San Vicente 2♂, Sells ♀, Tucson 28♀107♂, (10 mi. E.) ♂, (18 mi. S.) ♂, Tucson Mountains ♀6♂; Pinal Co.: Boyce Thompson Southwestern Arboretum 38♂, Coolidge (17 mi. N. W.) ♀2♂, Floy (11 mi. S. W.) ♀8♂, Florence Junction ♀, Oracle 4♀♂, Pepper Sauce Canyon (Santa Catalina Mountains) ♂, Picacho Pass 20♀, Santa Catalina Mountains ♂, Toltec (10 mi. S.) ♀; Santa Cruz Co.: Canelo 2♀♂, Madera Canyon (Santa Rita Mountains) ♂, Patagonia 2♀, Santa Rita Mountains 13♀14♂; Yavapai Co.: Ash Fork♀, Bradshaw Mountains♂, Campe Verde 3♀, Congress Junction ♀♂, Cottonwood (8 mi. N. E.) 4♀, Dewey ♀2♂, Jerome (12 mi. S.) ♀, Mt. Mingus (6 mi. S. W.) ♂, Seligman ♂, (7 mi. W.) 2♀, Yarnell to Prescott ♂; Yuma Co.: Palm Canyon (Kofa Mountains) ♂, Yuma 2♀♂, (15 mi. N.) 2♀, (30 mi. N.) ♀. CALIFORNIA. Fresno Co.: Coalinga (22 mi. W.) 7♀; Imperial Co.: Beal's Well (18 mi. N. E. Calipatria) ♀, (4.6 mi. N. E.) ♀, Calexico ♂, El Centro (E. of) ♀; Inyo Co.: Antelope Springs (8 mi. S. W. Deep Springs) 5♀2♂, Big Pine Creek (5 mi. S. W. Big Pine) ♀, Deep Springs (22 mi. E. Bishop) 2♀, Inyo Mountains (12 mi. E. Lone Pine) ♀, Mazourka Canyon (Inyo Mountains) 2♂, Surprise Canyon (Panamint Mountains) 5♂, Westgard Pass (4 mi. W.) 6♀♂, (7 mi. W.) 6♀; Riverside Co.: Andreas Canyon (4 mi. S. Palm Springs) ♀, Cathedral City ♂, Coachella Valley (5 mi. E. Palm Springs) ♂, Gavilan (4 mi. S. E. of E. end Lake Mathews) ♀, Hayfield Road (21 mi. N. E. of N. E. end Salton Sea) 4♀, Palm Desert ♀♂, Palm Springs ♀4♂, Palm Springs Station (7 mi. N. W. Palm Springs) ♀, Pinyon Flat (16 mi. S. W. Palm Springs) ♂, Riverside 2♀♂, Soboba Hot Springs ♀, Taquitz Canyon (2 mi. S. E. Palm Springs) ♀, Whitewater Canyon (8 mi. N. W. Palm Springs) ♂; San Bernardino Co.: Cushinbury Springs (N. side San Bernardino Mountains) ♀, Earp (10 mi. N.) ♀, San Bernardino ♀, Victorville ♀; San Diego Co.: Anza-Borego Desert State Park ♀, Borego ♀5♂, Box Canyon (15 mi. S. W. Borego) ♂, Jacumba 2♀2♂, Mason Valley (16 mi. S. W. Borego) ♂, Palm Canyon (8 mi. N. W. Borego) ♀. NEVADA. Curchill Co.: Hazen (3 mi. W.) ♂; Douglas Co.: Topaz Lake ♂♀; Lyon Co.: Dayton ♀, Yerington 35♀25♂; Washoe Co.: Sparks ♂, Sutcliffe 2♀. NEW MEXICO. Dona Ana Co.: Las Cruces ♀, Rincon ♀; Hidalgo Co.: Lordsburg (10 mi. N. E.) ♀, Rodeo 7♀, (14 mi. N.) ♀, (18 mi. N.) 2♀; Santa Fé

Co.: Santa Fé ♂. TEXAS. El Paso Co.: El Paso 2♂. UTAH. Washington Co.: Anderson's Ranch (8 mi. N. Hurricane) ♂, St. George 4♂, Veyo 2♀ ♂. MÉXICO. Baja California: El Mayor (2 mi. S.) ♂, San Agustín (20 mi. W.) ♀; Baja California Territorio Sur: Canipolé ♀2♂, Coyote Cove (Bahía Concepción) ♀ ♂, La Paz ♂, Sierra de la Laguna (Big Canyon?) ♀; Sonora: Alamos (10 mi. W.) 3♂, Guaymas 4♀, (16 mi. N.) 2♂, (37 mi. N.) ♀ ♂.

TABLE 2.—Summary of Flower Records for *Nomia t. tetrazonata* Cockerell

Plant Data			Records of *N. t. tetrazonata*			
FAMILY	Number of genera	Number of species	Number of collections	Number of females	Number of males	Total number of bees
Asclepiadaceae	2	2	4	4	2	6
Boraginaceae	1	1	1	0	1	1
Capparidaceae	3	3	4	6	0	6
Compositae	7	7	11	5	13	18
Convolvulaceae	1	1	2	6	2	8
Cruciferae	1	1	1	0	1	1
Euphorbiaceae	2	2	6	2	7	9
Gramineae	1	1	1	1	0	1
Labiatae	1	1	1	0	1	1
Leguminosae	8	8	35	41	51	92
Liliaceae	1	1	1	0	1	1
Malvaceae	1	1	2	2	0	2
Myrtaceae	1	1	1	0	2	2
Nyctaginaceae	2	2	3	2	1	3
Polygonaceae	2	5	9	23	10	33
Rhamnaceae	1	1	1	23	0	23
Sapindaceae	1	1	1	1	1	2
Scrophulariaceae	1	1	1	1	0	1
Solanaceae	1	2	8	16	0	16
Vitaceae	1	1	1	0	3	3
Zygophyllaceae	2	2	13	15	9	24
Total	41	45	107	148	105	253

FLOWER RECORDS. ASCLEPIADACEAE: *Asclepias* sp. 4♀ ♂, *Philibertia heterophylla* ♂. BORAGINACEAE: *Heliotropium* sp. ♂. CAPPARIDACEAE: *Cleome* sp. 2♀, *Cleomella longipes* ♀, *Wislizenia refracta* 3♀. COMPOSITAE: *Baccharis* sp. ♀3♂, *B. sarothroides* ♀, *Chrysothamnus* sp.♀, *Encelia* sp.♀, *E. farinosa* 2♂, *Gutierrezia* sp.♂, *G. Sarothrae* ♀, *Heterotheca* sp. 4♂, *Hymenothrix Wislizeni* ♂, *Verbesina* sp. 2♂. CONVOLVULACEAE: *Cuscuta* sp. 2♂, *C. umbellata* 6♀. CRUCIFERAE: *Lepidium* sp. ♂. EUPHORBIACEAE:

Croton californicus ♀ 4 ♂, *Euphorbia* sp. ♀ 3 ♂. Gramineae: *Zea Mays* ♀. Labiatae: *Hyptis Emoryi* ♂. Leguminosae: *Acacia* sp. 4 ♀ 14 ♂, *Cercidium* sp. ♀ ♂, *C. floridum* ♀ 4 ♂, *Dalea* sp. 5 ♀ ♂, *Glycine Max* ♀, *Lotus scoparius* 8 ♀, *Medicago sativa* 2 ♀ 2 ♂, *Melilotus* sp. ♀ ♂, *M. alba* 14 ♀ 10 ♂, *Prosopis* sp. 4 ♀ ♂, *Prosopis* sp./*Acacia* sp. 17 ♂. Liliaceae: *Nolina parryi* ♂. Malvaceae: *Gossypium* sp. 2 ♀. Myrtaceae: *Melaleuca* sp. 2 ♂. Nyctaginaceae: *Allionia incarnata* ♀ ♂, *Boerhaavia* sp. ♀. Polygonaceae: *Antigonon* sp. ♀ ♂, *Eriogonum* sp. 11 ♀ 8 ♂, *E. fasciculatum* ♀, *E. heermannii* 5 ♀ ♂, *E. inflatum* 4 ♀, *E. nodosum* ♀. Rhamnaceae: *Condalia* sp. 23 ♂. Sapindaceae: *Sapindus* sp. ♂, *S. Sponaria* ♀. Scrophulariaceae: *Penstemon Palmeri* ♀. Solanaceae: *Solanum* sp. ♀, *S. elaeagnifolium* 14 ♀, *S. rostratum* ♀. Vitaceae: *Cissus trifoliata* 3 ♂. Zygophyllaceae: *Larrea tridentata* 12 ♀ 9 ♂, *Kallstroemia grandiflora* 3 ♀.

The above flower records are summarized in table 2.

Seasonal Activity. Table 5 gives the seasonal activity of the adults.

Nomia (*Curvinomia*) *tetrazonata uvaldensis* Cockerell, new combination

(Fig. 6; Map 1; Table 5)

Nomia (*Paranomia*) *uvaldensis* Cockerell, 1930, p. 13 (tax., ♀).

Nomia (*Paranomia*) *zabriskii* Cockerell & Blair, 1930, p. 13 (tax., ♂), new synonymy.

Nomia zabriskii: Blair, 1930, p. 17 (tax.).

Nomia parksi Cockerell, 1934b, p. 7 (tax., ♀), new synonymy.

Nomia uvaldensis: Cockerell, 1934b, p. 7 (tax.).

Nomia (*Acunomia*) *uvaldensis:* Michener, 1951, p. 1128 (cat.).

Nomia (*Acunomia*) *zabriskii:* Michener, 1951, p. 1128 (cat.).

Nomia (*Acunomia*) *parksi:* Michener, 1951, p. 1128 (cat.).

Nomia (*Acunomia*) *foxii:* Wille, 1958, p. 544 (heart) (misidentification).

Nomia (*Paranomina*) *parksi:* Cross, 1958a, p. 1266 (tax.).

Nomia (*Paranomina*) *uvaldensis:* Cross, 1958a, p. 1266 (tax.).

Nomia (*Paranomina*) *zabriskii:* Cross, 1958a, p. 1266 (tax.).

N. uvaldensis and *zabriskii* are both available names for this subspecies. Since *uvaldensis* has line preference and its holotype is in better condition than that of *zabriskii,* it should be used. *N. parksi* is the same as *uvaldensis.*

N. t. uvaldensis can be separated from *t. tetrazonata* by the characters given below.

MALE. (8) Tergum 2 with groove in center, punctate part of postgradular area about twice as wide as colored band; groove shallow and U-shaped; depressed area slightly and gradually depressed, much wider than colored band; terga 2 to 4 with punctures shallow and some punctures not sharp.

FEMALE. (25) Tergum 1 with scattered, minute punctures much finer than those of mesoscutum. (26) Tergum 2 with punctures like those of tergum 1, apical higher portion with few scattered punctures. (27) Terga 3 and 4 with minute, scattered punctures like those of tergum 1 or finer.

VARIATION. Little variation has been noted in the few specimens of this subspecies examined. No intergrades have been found between *t. uvaldensis* and *t. tetrazonata.* This form may be found to be a good species. Since the differences between the two subspecies of *tetrazonata* are much less than between other species of North American banded *Nomia,* and since the distributions are allopatric with few specimens known from near the meeting of their ranges, it seems best to consider them as the same species.

TYPE MATERIAL. Cockerell gave the following data on the holotypes of both *uvaldensis* (female) and *zabriskii* (male): Uvalde, Texas, September 30, 1899 (J. L. Zabriskie collection, presented by H. F. Wickman). These specimens also bear the date June 18-20. From the label data it seems that these specimens were collected by H. F. Wickman on June 18-20, and received by J. L. Zabriskie on September 30, 1899. The latest date I have seen on any other specimen from Texas is August 25. The holotype of *uvaldensis* has the following parts missing: right front leg, left middle leg beyond the middle of the femur, right middle leg beyond femur, antennae, mouth parts and mandibles. The holotype of *zabriskii* has the following parts missing: antennae, two tarsal segments of right front leg, four tarsal segments of left hind leg, hidden sterna and genital capsule. This specimen has also lost the color of the abdominal bands and has the integument discolored. Cockerell mentions the antennae as being missing on these specimens, but the rest of the damage must have occurred since their description. In *zabriskii* this might have happened when Blair (1930) dissected the genitalia and hidden sterna. These holotypes along with that of *parksi,* female, Bexar County, Texas, May 27, 1931 (H. B. Parks), are in the American Museum of Natural History.

Range. This subspecies ranges from eastern New Mexico and Texas southward to the States of Durango and San Louis Potosí in Mexico (map 1).

List of Localities. New Mexico. Guadalupe Co.: Santa Rosa 2 ♂; Quay Co.: Tucumcari ♀. Texas. Bexar Co. 2 ♀: Fort Sam Houston ♂; Brewster Co.: Big Bend National Park ♂, Santa Elena Canyon (Big Bend National Park) 10 ♀; Dawson Co.: Lamesa ♂; Dimmit Co.: Carrizo Springs 3 ♀ 14 ♂; Hidalgo Co. ♀ 3 ♂: Hidalgo 2 ♀ 6 ♂; Jim Wells Co.: Alfred 3 ♀ 39 ♂; Maverick Co.: Quemado ♀ ♂; Pecos Co.: Fort Stockton ♂; San Patricio Co.: Lake Corpus Christi ♂; Starr Co. 6 ♀ 2 ♂; Rio Grande City (5 mi. E.) ♀; Uvalde Co.: Uvalde ♀ 2 ♂; Webb Co.: Laredo ♂, (21 mi. N.) ♀, (18 mi. N.) ♀ ♂; Zavala Co.: Nueces River ♀. México. Chihuahua: Chihuahua ♀; Coahuila: Gloria (S. of Monclova) ♀, Piedras Negras (192 km. S.) ♀; Durango: La Loma (15 mi. S. W. Torreón) 4 ♀, Pedriceña ♀ ♂; Nuevo Leon: Montemorelos ♂, Vallecillo 4 ♀ 5 ♂; San Luis Potosí: Santa Domingo ♂.

Flower Records. Compositae: *Baccharis glutinosa* ♀. Labiatae: *Teucrium cubense* 5 ♀ ♂. Leguminosae: *Acacia* sp. ♂, *A. Greggii* 3 ♀ 39 ♂, *Cercidium texanum* ♂, *Melilotus alba* 2 ♂, *Parkinsonia aculeata* 2 ♀ ♂, *Prosopis* sp. ♀, *P. juliflora* ♂. Solanaceae: *Solanum elaeagnifolium* ♀.

Seasonal Activity. Table 5 gives the seasonal activity of the adults.

Subgenus *Acunomia* Cockerell

Nomia (*Acunomia*) Cockerell, 1930, p. 11 (type species: *N. nortoni* Cresson); Sandhouse, 1943, p. 522; Michener, 1944, p. 251; Michener, 1951, p. 1127; Cross, 1958a, p. 1263.

When first proposed by Cockerell, *Acunomia* included *nortoni* and the *melanderi* complex. Michener (1951) included all the metallic-banded *Nomia* of the United States in *Acunomia*. Cross (1958) placed *robinsoni* in *Acunomia*, and considered *Curvinomia* (= *Paranomina*) as a distinct subgenus with the same species as are included here.

The characters that separate *Acunomia* from the North American *Curvinomia* are given below.

Male. Antenna tapering and reaching beyond thorax, last flagellar segment pointed or rounded. Posterior tibia produced anteriorly and distally into a large lobe hiding all or almost all of

tibial spurs in side view; tibia not triangular in shape as seen from side (fig. 7). Tergum 2 (sometimes 1) to 5 with colored bands. Sternum 3 with ventrolateral process. Sternum 5 with setae in row behind lateroapical hairy pads completely fused except in *robinsoni;* median apical process arising from median longitudinal ridge (fig. 24). Penis valve with ventral opening; gonostylus with small, inward pointing, hooklike process at base (fig. 30).

FEMALE. Middle tibial spur with few, uneven, coarse teeth along apical third. Tergum 2 (sometimes 1) to 5 with metallic bands.

Nomia (*Acunomia*) *nortoni* Cresson

This is the largest species of *Acunomia,* and can be easily distinguished from any other North American bee by its large size and the integumental colored abdominal bands.

MALE. *Structure:* (1) Mandible with large rounded lobe on posterior margin. (2) Clypeus with bare part impunctate, nearly flat or slightly depressed in center or with weak longitudinal carina; subapical area slightly depressed. (3) Last flagellar segment acutely pointed, one and one-half to two times as long as second flagellar segment. (4) Pronotum without carina on posterior, dorsal edge. (5) Scutellum deeply to slightly depressed in center, lateral higher parts less densely punctate than surrounding area. (6) Metepisternum coarsely wrinkled. (7) Propoedum with anterior groove widened to narrowed medially. (8) Tegula emarginate or straight on outer edge, subtruncate posteriorly. (9) Front wing length (see section on methods) about 11.2 mm. (range: 10.6-12.2, one specimen 10.0). (10) Middle tibial spur straight. (11)Posterior femur as broad as long, large basal and lateral areas nearly impunctate and shining. (12) Posterior tibia produced anteriorly and distally into large rounded lobe which hides tibial spurs in side view (fig. 7). (13) Metasomal tergum 1 coarsely punctate except for band of minute punctures at base of apical, depressed, hyaline portion; median width of band varies from six rows of punctures to few scattered punctures, width of band reduced laterally. (14) Terga 2 to 4 with few coarse punctures like those on tergum 1 on raised part of postgradular area; otherwise with small, close punctures except on colored bands. (15) Sternum 3 with ventrolateral, toothlike process twice as wide as high. (16) Ventroapical, median part of gonobase not produced. (17) Penis valve with large triangular ventral opening; valve produced laterally into two projections, the outer acute, the inner narrowly

rounded; tip robust and pointed (fig. 30). *Pubescence*: (18) Face, including upper third of clypeus and lateral part of scape, covered with short, appressed, plumose, yellow or yellow-white hairs. (19) Longest hairs of face one-half to two-thirds as long as scape. (20) Anterior margin of genal area, along eye, bare or with short, appressed, plumose hairs. (21) Hair of anterior part of mesoscutum, of posterior lobe of pronotum, and anterior part of mesepisternum yellow-white to white. (22) Median mesoscutal line and notaulus obscured by hairs except posteriorly. (23) Metanotum with anterior forth to half obscured by short, plumose hairs. (24) Tegula covered with fine simple hairs posteriorly. (25) Propodeal hairs white. (26) Longest hairs of tergum 2 as long as to twice as long as lateral width of colored band. (27) Tergum 4 usually and sometimes tergum 3 with some black hairs, terga 2 with hairs all white. *Color:* (28) Mandible translucent yellow, orange, or red-brown, with subapical red area. (29) First seven flagellar segments yellow to orange below, other segments orange below. (30) Legs black to red-brown except tarsi and undersides and apices of tibiae, which are yellow to orange; last four tarsal segments of middle and hind legs brown above. (31) Stigma brown, about same color as most veins; vein R, intersection of M and Cu, and distal end of V black to dark brown. (32) Terga 2 to 5 with apical colored bands; band of tergum 5 absent laterally; band color variable, blue, green or yellow with purple, pink or gold iridescence.

Female. *Structure:* (33) Clypeal margin truncate to slightly emarginate medially; part overhanding base of labrum not hyaline; longitudinal carina distinct to weak; clypeus evenly punctate. (34) Face with elevated portion below antennae impunctate or with few punctures. (35) Pronotum without carina on posterior, dorsal edge. (36) Mesoscutum and scutellum with scattered punctures; scutellum slightly depressed or flat in center. (37) Mesepisternum with coarse wrinkles. (38) Propodeum with anterior groove sometimes widened medially. (39) Tegula slightly emarginate or straight on outer edge, subtruncate posteriorly. (40) Front wing length (see section on methods) about 9.9 mm. (range: 9.2-10.7, one specimen 8.4). (41) Metasomal tergum 1 with medium punctures at sides, becoming smaller and more scattered towards center except small oval center area usually with much closer punctures, and band of minute punctures at base of apical, depressed, hyaline portion; median width of band one-half to

two-thirds width of hyaline portion. (42) Tergum 2 with medium punctures at sides of basal area, becoming much finer toward center. (43) Tergum 3 with gradular ridge distinct and with few scattered punctures. *Pubescence:* (44) Longest hairs of face as long as or longer than distance from antenna to inner eye margin. (45) Anterior margin of genal area, along eye, bare or with short, appressed, plumose hairs. (46) Mesoscutal hairs mostly dark. (47) Notaulus obscured; median mesoscutal line visible or obscured anteriorly by long hairs. (48) Metanotum completely to its anterior third obscured by short, plumose hairs; longer black hairs present or absent. (49) Tegula covered with fine simple hairs posteriorly. (50) Tergum 1 with lateral part of depressed, hyaline portion obscured by subappressed mat of hairs. (51) Terga 3, 4 and sometimes 2 with some black hairs. *Color:* (52) Antenna light brown below. (53) Stigma brown, about same color as most veins; vein R, sometimes intersection of M and Cu, and distal end of V black to dark brown. (54) Legs dark brown. (55) Terga 2 to 5 with apical colored bands; band color variable, yellow or green with gold, pink or yellow iridescence.

Nomia (*Acunomia*) *nortoni nortoni* Cresson

(Figs. 7, 24 and 30; Diagrams a and b; Map 4; Tables 3 and 5)

Nomia nortoni Cresson, 1868, p. 385 (tax., ♂, ♀); Cresson, 1872, p. 256 (rec.); Cresson, 1875, p. 722 (rec.); Patton, 1879, p. 366 (in part) (tax.); Snow, 1880, p. 95 (rec.); Cragin, 1886, p. 211 (rec.); Cresson, 1887, p. 294 (cat.); Robertson, 1892, p. 105 (fls.); Cockerell, 1893, p. 339 (rec.); Fox, 1893, p. 134 (tax.); Dalla Torre, 1896, p. 168 (in part) (cat.); Cockerell, 1898b, p. 50 (tax.); Cockerell, 1898c, p. 50 (tax.); Cockerell, 1898d, p. 32 (tax.); Birkman, 1899, p. 244 (rec.); Bridwell, 1899, p. 210 (rec.); Cockerell, 1899a, p. 4 (rec.); Cockerell, 1899b, p. 7 (cat.); Cockerell, 1906a, p. 298 (rec.); Cockerell, 1906b, p. 279 (tax.); Swenk, 1907, p. 294 (rec.); Cockerell, 1914, p. 411 (fls.); Cresson, 1916, p. 108 (tax.); Cockerell, 1917, p. 190 (rec.); High, 1921, p. 307 (biol.); Blair, 1930, pp. 7 and 17 (tax.); Cockerell, 1934b, p. 7 (biol.); Sandhouse, 1943, p. 522 (tax.).

Nomia cressoni: Vachal, 1897, p. 92 (in part) (tax., ♀) (misidentification).

Paranomia nortoni: Cockerell, 1900, p. 407 (rec.); Cockerell, 1904, p. 42 (tax.); Robertson, 1925, p. 434 (fls.); Robertson, 1928, pp. 10, 65, 120, 123, 130, 134, 148 and 198 (fls.); Brimley, 1938, p. 457 (rec.).

Nomia nortoni var. *plebeia* Cockerell, 1910a, p. 276 (tax.).

Nomia (*Paranomia*) *nortoni:* Cockerell, 1910b, p. 290 (in part) (tax.).

Nomis [sic] nortonii: Parks, 1928, p. 263 (biol.).

Nomia (*Acunomia*) *nortoni:* Cockerell, 1930, p. 11 (tax.); Michener, 1951, p. 1127 (in part.) (cat.); Wille, 1956, p. 450 (musculature); Cross, 1958a, p. 1266 (tax.); Krombein, 1958, p. 233 (cat.); Mitchell, 1960, p. 506 (tax., ♂, ♀).

Nomia (*Acunomia*) *nortoni plebeia:* Cockerell, 1930, p. 16 (tax.).

Nomia (*Acunomia*) *nortoni* var. *plebia:* Michener, 1951, p. 1128 (*lapsus calami*) (cat.).

In his description of this species Cresson said the male had three hind tibial spines. The male syntype has the hind tibial spurs on one leg obscured by glue, and on the other leg some of the hair has become matted together giving the impression of a third tibial spur on that leg. Cresson's error led Westwood to describe *cressoni.*

Male. (8) Tegula emarginate, occasionally slightly so, on outer edge. (12) Hind tibial lobe with raised area of outer surface limited to basal half, raised area not forming distinct ridge; lobe at least 1.8 mm. wide (fig. 7). (19) Hairs short, longest hairs of face about half as long as scape. (20) Anterior margin of genal area, along eye, bare. (26) Longest hairs of tergum 2 about as long as lateral width of colored band.

Female. (37) Scutellum slightly depressed or flat in center. (40) Tegula slightly emarginate on outer edge. (45) Hairs short, longest hairs of face about as long as distance from antenna to inner eye margin. (46) Anterior margin of genal area, along eye, bare. (48) Median mesoscutal line not obscured anteriorly by long hairs.

Variation. In spite of its wide range, this subspecies exhibits comparatively little interpopulational variation in the characters studied. The variation that does occur is considered in the descriptions above and is not distributed in a clinal fashion, but occurs randomly throughout the range.

Type Material. *N. nortoni* was described from three females and a male: Female, New Mexico, summer of 1867 (Samuel Lewis), Academy of Natural Sciences of Philadelphia, type number 2135; female, Colorado (James Ridings), Academy of Natural Sciences of Philadelphia, type number 2535.3; male, same data with, type number 2535.2; female, Kansas (Edward Norton collection),

location now unknown. In 1916 Cresson designated the New Mexico specimen as the lectotype. The female holotype of *N. nortoni* var. *plebeia*, Fedor, Texas, June 18, 1905 (G. Birkman), is in the U. S. National Museum, type number 55861.

RANGE. This subspecies ranges from Pennsylvania to the Rocky Mountains and south into southern Texas and Florida (map 4). West of the Rocky Mountains it is replaced by a closely related, smaller species, *N. melanderi*. An apparent exception to this statement is one specimen of *nortoni* collected in southern Idaho; it is presumably mislabeled. It is unlikely that this species occurs in southern Idaho since it has never been found there by G. E. Bohart or G. F. Knowlton who have collected extensively in that area.

LIST OF LOCALITIES. ALABAMA. Mobile Co.: Mobile ♀ ♂; Dallas Co.: Selma ♀ ♂. ARKANSAS. Ashley Co.: Wilmot (6 mi. E.) ♂; Sevier Co.: De Queen ♂. COLORADO. Clear Creek Co.: Mt. Evans (Bear Creek Canyon) ♂; Custer Co.: Westcliffe; * El Paso Co.: Manitou ♂. FLORIDA. Alachua Co.: Gainesville 3 ♀ 5 ♂; Calhoun Co.: Blountstown ♀; Jackson Co.: Cottondale ♀; Jefferson Co.: Monticello 7 ♀, Lamont ♂; Levy Co.: Morriston 119 ♀ & ♂; Madison Co. ♂; Marion Co.: Dunnellon ♀; Pasco Co.: Zephyrhills 20 ♀ ♂; Sumter Co. ♂; Suwannee Co.: Bradford 3 ♀ 5 ♂, Suwannee Springs ♀; Taylor Co.: Perry ♂; County ?: Swain 4 ♂. GEORGIA. Clarke Co.: Athens ♀; Crawford Co.: Roberta ♀; Decatur Co.: Bainbridge ♀ ♂, Butler's Ferry ♂, Spring Creek 2 ♀; Dougherty Co.: Albany ♀; Jefferson Co.: Wadley ♀; Thomas Co.: Thomasville ♂. IDAHO. Caribou Co.: Soda Springs ♀. ILLINOIS. Adams Co. ♀; Alexander Co.: Cache ♀; Champaign Co.: Urbana ♀; Macoupin Co.: Carlinville; * Woolford Co.: Kappa ♀. KANSAS. Allen Co. ♀; Barber Co.; * Cheyenne Co. 2 ♂; Douglas Co. 46 ♀ 9 ♂: Baldwin City 2 ♀ ♂, Lawrence ♀; Finney Co.: Garden City ♀ 7 ♂; Kearny Co. 3 ♀ 2 ♂; Neosho Co. ♂; Pottawatomie Co.: Onaga ♂; Riley Co. 14 ♀ 12 ♂: Manhattan ♀; Sumner Co. ♀ ♂; Wallace Co. 10 ♀: Wallace 2 ♀ 10 ♂; Wilson Co. ♀. LOUISIANA. Ascension Co.: Darrow 2 ♀; Cameron Co.: Creole 17 ♀ 18 ♂; East Baton Rouge Co.: Baton Rouge 2 ♀ 3 ♂; Orleans Co.: New Orleans ♂; Point Coupee Co.: New Roads ♂ 1?. MARYLAND. Allegany Co.: Cumberland ♀. MISSISSIPPI. Bolivar Co.: Benoit ♂; Noxubee Co.: Shuqualak 11 ♀. MISSOURI. Miller Co.: Lake Ozark ♂; Taney Co.: Branson ♀. NEBRASKA. Cass Co.: Union ♀; Clay Co.: Harvard 2 ♀; Douglas Co.: Omaha ♀; Dundy Co.: Haigler ♂; Lancaster

Co.: Lincoln 6 ♀ ♂; Otoe Co.: Nebraska City 13 ♀ 5 ♂; Scotts Bluff Co.: Mitchell 4 ♀ 10 ♂. NEW MEXICO. Chaves Co.: Roswell 3 ♀ 8 ♂; San Miguel Co.: Las Vegas ♂; Socorro Co.: Magdalena Mountains ♀. NORTH CAROLINA. Ashe Co.: New River ♀; Carteret Co.: Boque ♀ ♂; Hyde Co. 3 ♀ 6 ♂; Pasquotank Co.: Elizabeth City.* OKLAHOMA. Alfalfa Co.: Cherokee ♀; Carter Co.: Ardmore 3 ♀; Garvin Co.: Paul's Valley 3 ♀; Mc Curtain Co.: Idabel ♀. PENNSYLVANIA. Allegheny Co. ♀. SOUTH CAROLINA. Greenville Co.: Greenville ♀. SOUTH DAKOTA. Bookings Co.: Bookings ♂. TEXAS. Aransas Co. 3 ♂; Bastrop Co. ♂: Smithville ♂; Bee Co.: Beeville ♀; Bexar Co. ♀ 5 ♂: Fort Sam Houston ♂, San Antonio 8 ♀ 6 ♂; Blanco Co.: Johnson City 3 ♂, Round Mountain ♀; Bosque Co.; * Brazos Co.: College Station 3 ♀; Cameron Co.: Port Isabel ♂; Camp Co.: Pittsburg 3 ♀; Collin Co.: McKinney ♀; Coryell Co.: Gatesville 2 ♀; Dallas Co.: Dallas 2 ♀ 17 ♂; Denton Co.: Denton 3 ♀; Donley Co.: Clarendon ♀; Duval Co.: San Diego ♂; Eastland Co. ♀; Frio Co. 6 ♀ 4 ♂; Galveston Co.: High Island 2 ♀; Gillespie Co.: Stonewall ♂; Goliad Co.: Goliad ♀; Gonzales Co.: Palmetto State Park 8 ♀ ♂; Grayson Co.: Sherman ♀; Harris Co.: Baytown ♀; Hemphill Co.: Canadian ♂; Henderson Co.: Athens ♀; Hidalgo Co.: Alamo ♂; Hunt Co.: Quinlan ♀; Jefferson Co.: Sabine (10 mi. S.) ♀; Kaufman Co.: Rosser 3 ♀; Kerr Co.: Kerrville 2 ♀ 7 ♂; Kleberg Co.: Kingsville 8 ♀, Los Olmos Creek ♂; Lamar Co.: Paris 4 ♀ ♂; La Salle Co.: Cotulla 3 ♂; Lavaca Co.: Sweet Home ♂; Lee Co. ♀ 3 ♂: Fedor 9 ♀ 3 ♂, Giddings 28 ♀ 27 ♂, Old Dime Box 3 ♂; Limestone Co.: Mexia ♀; Matagorda Co.: Bay City ♀, Matagorda 2 ♀; McLennan Co.: Eddy ♀ ♂, McGregor 2 ♂, Waco 2 ♀; Medina Co. ♀; Mills Co.: Goldthwaite ♀; Montague Co.: Forestburg 2 ♀ 2 ♂; Montgomery Co.: Magnolia 4 ♀; Nueces Co. 2 ♂: Corpus Christi ♀, Corpus Christi (Naval Air Station) ♀; Red River Co.: Clarksville ♀; Refugio Co.: Tivoli (5 mi. S. W.) 44 ♀ ♂; Tarrant Co.: Fort Worth ♀; Travis Co.: Austin 33 ♀ 13 ♂; Trinity Co.: Trinity ♂; Uvalde Co.: Concan ♂, Sabinal ♀; Val Verde Co.: Devil's River 2 ♀; Victoria Co.: Victoria ♀; Webb Co.: Laredo ♀ 6 ♂; Wichita Co.: Wichita Falls ♂; Williamson Co.: Round Rock ♀, Taylor ♂. VIRGINIA. Norfolk Co.: Dismal Swamp (Stumpy Lake?) 1?. MEXICO. Coahuila: Piedras Negras (192 km. S.) ♀.

FLOWER RECORDS. ANACARDIACEAE: *Rhus,* sp. 3 ♀ 6 ♂, *R. copallina* ♀. CLETHRACEAE: *Clethra* sp. ♀ ♂. COMPOSITAE: *Aster*

sp. ♀, *Cirsium* sp. 7 ♀ ♂, *C. altissimum* ♀, *C. vulgare,** *Coreopsis cardaminefolia* ♀ 6 ♂, *Engelmannia pinnatifida* ♂, *Gaillardia* sp. 12 ♀ 20 ♂, *Grindelia* sp. ♀, *G. squarrosa,** *Helenium autumnale* 3 ♀, *Helianthus* sp. ♀ ♂, *H. Maximiliani,** *Ratibida columnifera* ♂, *R. pinnata* ♀, *Solidago* sp. 13 ♀ 4 ♂, *S. rigida,** yellow Compositae ♂. CONVOLVULACEAE: *Euipomoea* sp. ♀. EUPHORBIACEAE: *Euphorbia marginata* ♀. HYDROPHYLLACEAE: *Phacelia* sp. 44 ♀ 2 ♂. LABIATAE: *Brazoria truncata* ♀, *Marrubium vulgare* 2 ♀ ♂, *Mentha longifolia,** *Monarda* sp. ♀, *M. citriodora* 2 ♀, *M. punctata* 3 ♂, *Pycnanthemum virginianum,** *P. flexuosum.** LEGUMINOSAE: *Amorpha fruticosa* ♀, *Cassia cinerea* 2 ♀, *C. fasciculata* 2 ♀, *Dalea aurea* ♂, *D. multiflora* 2 ♂, *Desmodium paniculatum,** *Medicago sativa* 2 ♀ 7 ♂, *Melilotus alba* 10 ♀ 6 ♂, *Petalostemum* sp. ♀, *P. purpureum,** *P. microphyllum,** *Prosopis* sp.* LILIACEAE: *Yucca glauca.** MALVACEAE: *Callirhoë leiocarpa* ♂, *Gossypium* sp. 2 ♀ ♂. OLEACEAE: *Ligustrum* sp. ♀. ONAGRACEAE: *Oenothera biennis.** POLYGONACEAE: *Polygonum* sp. ♂. PONTEDERIACEAE: *Pontederia cordata* ♀. RUBIACEAE: *Borreria* sp. 3 ♂. SOLANACEAE: *Lycium* sp. ♂, *L. halimifolium,** *Solanum* sp. 2 ♀, *S. rostratum* 3 ♀, *S. Torreyi* 2 ♀. UMBELLIFERAE: *Eryngium* sp. ♂, *E. yuccifolium.** VERBENACEAE: *Verbena officinalis* 4 ♀.

As shown above, *N. n. nortoni* has been found on a large variety of flowers. These data are summarized in table 3. Cockerell (1934b) states that Parks observed this subspecies on 83 species of plants in Texas.

PARASITES. Only one parasite has been recorded from this subspecies, the mite *Disparipes texanus* (Cockerell, 1910a, p. 276), found on the adult bee. Dr. E. A. Cross identified mites from the mesothoracic hair of a male from Austin, Texas, as *Imparipes americanus* (Acarina: Scutacaridae). Mr. R. C. Funk identified mites from the vertex of the head of a female from Athens, Texas, as *Glyphanoetus* sp. (Acarina: Anoetidae).

BIOLOGY. Some 20 years ago the late Dr. R. H. Beamer collected two cell clusters of *N. n. nortoni* near Lawrence, Kansas. Dr. C. D. Michener has kindly turned these cell clusters over to me for dissection and study. The cell clusters were found, along with many others, in a recently plowed corn field; they must have been thrown out by the plow. There must have been a recent rain, because two cells were partially filled with soil that seems to have been washed into them. These plugs of soil could only have been

TABLE 3.—Summary of Flower Records for *Nomia nortoni nortoni* Cresson

Plant Data*			Records of *N. n. nortoni*			
FAMILY	Number of genera	Number of species	Number of collections	Number of females	Number of males	Total number of bees
Anacardiaceae	1	1	2	4	6	10
Clethraceae	1	1	1	1	1	2
Compositae	10	12	18	41	35	76
Convolvulaceae	1	1	1	1	0	1
Euphorbiaceae	1	1	1	1	0	1
Hydrophyllaceae	1	1	2	44	2	46
Labiatae	5	7	5	6	4	10
Leguminosae	8	11	13	18	16	34
Liliaceae	1	1	0	0	0	0
Malvaceae	2	2	3	2	2	4
Oleaceae	1	1	1	1	0	1
Onagraceae	1	1	0	0	0	0
Polygonaceae	1	1	1	0	1	1
Pontederiaceae	1	1	1	1	0	1
Rubiaceae	1	1	2	0	3	3
Solanaceae	2	3	4	7	1	8
Umbelliferae	1	1	1	0	1	1
Verbenaceae	1	1	1	4	0	4
Total	40	48	57	131	72	203

* Records from the literature are included under this heading.

formed when the cells were inverted after being thrown out by the plow. Thus the cell clusters have been weathered, and possibly the years of storage have further changed their shape. Since the cell of *N. nortoni* has never been described, these cell clusters provide some important information on the biology of this species.

The cell cluster seems to be of the type that is surrounded by a cavity and supported upon pillars with the cells in vertical orientation, as shown by Sakagami and Michener (1962, fig. 2) for the Asiatic *N. punctata* Westwood. They mention that another Asiatic species, *N. ruficornis* Spinola, has a similar type of nest (p. 47). High (1921) states that the irregular cell cluster of *N. nortoni* is surrounded by a cavity, but Parks (1928) does not mention such a cavity. The larger cell cluster (diagram a) from Lawrence, which is 57 millimeters high by 83 millimeters long by 60 millimeters wide, contained nine cells; two open but at one time closed, two open and never closed, four with pollen balls, and one with pollen and large larva. The smaller cell cluster, which is not complete, con-

tained six cells; three open and partly full of dirt, two with adult females, and one side of another cell. High states the cell clusters contained from four to fourteen cells, the average being six or eight. The cell clusters are made of hard clay and the cells are lined with the same material. Parks mentions that the cells and burrow are lined with "foreign" soil. The walls of the cells are coated with a thin layer of hard, dark material. The cells are vertical, oval in shape, one side being flattener than the others, with a length of 17 to 19 millimeters and a width of 9.5 to 11.0 millimeters (diagram b). The minimum distance between cells was two millimeters, the maximum was much more than this. The completed cells are closed by a plug that is concave on the inside, 6 to 11 millimeters in length, and 6.5 to 7.5 millimeters in diameter at the bottom, becoming wider at the top. The feces are deposited in fine ribbons at the bottom of the cell; this fecal mass becomes very thin as it continues up the sides of the cell. For burrow depth see High (1921), Parks (1928) and Cockerell (1934b).

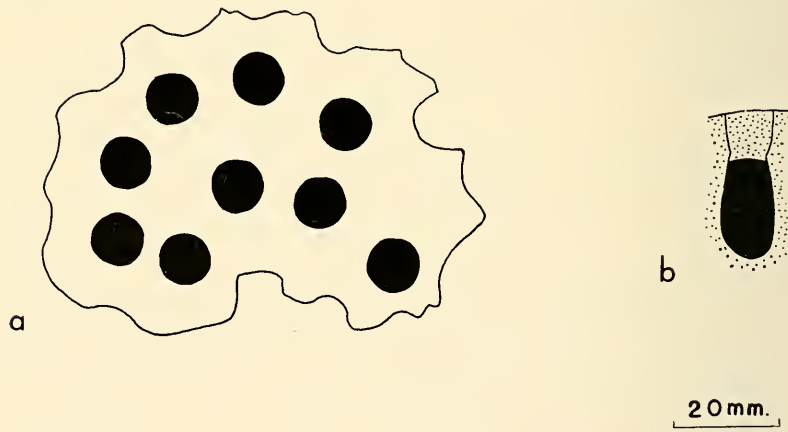

DIAGRAM a. Cross section of *N. n. nortoni* cell cluster.
DIAGRAM b. Cell of *N. n. nortoni*.

N. nortoni nests in dense aggregations and build up large populations at certain times, as does *N. melanderi*, but unlike *melanderi*, *nortoni* does not seem to prefer alkali soil. Parks found them nesting in cotton and corn fields, and High found them in a sweet potato field. Dr. H. V. Weems, Jr. (*in litt.*) reports *N. nortoni* nesting by the hundreds in a lawn at Morriston, Florida. Although *nortoni* cell clusters are surrounded by a cavity, *melanderi* has no such cavity (Stephen, 1959a; Bohart, 1952).

Seasonal Activity. Table 5 gives the seasonal activity of the adults. The specimen bearing the earliest date was taken at Dallas, Texas. *N. n. nortoni* seems to occur about a month earlier in Texas than in any other state. The latest date in table 5 was based on a specimen collected in Texas (no lacality given). The next latest date, October 14, was from a specimen collected at Cache, Illinois.

Nomia (Acunomia) nortoni cressoni Westwood, new combination

(Fig. 8; Map 4; Table 5)

Nomia cressoni Westwood, 1875, p. 218 (tax., ♂, ♀); Vachal, 1897, p. 92 (in part) (tax., ♀); Cockerell, 1898d, p. 33 (tax.); Cockerell, 1899b, p. 7 (cat.).

Nomia nortoni: Patton, 1879, p. 366 (in part) (tax.); Dalla Torre, 1896, p. 168 (in part) (tax.); Rau, 1943, p. 645 (rec.).

Nomia (*Paranomia*) *nortoni:* Cockerell, 1910b, p. 296 (in part) (tax.).

Nomia (*Acunomia*) *nortoni:* Michener, 1951, p. 1128 (in part) (cat.).

The status of this form has been confused, largely due to Cresson's description of *nortoni,* which is discussed above. The characters that separate this form from *n. nortoni* have not been previously recognized, but are important enough to give this form subspecific status, as seen by the description below.

Male. (8) Tegula slightly emarginate or usually straight on outer edge. (12) Hind tibial lobe with raised area of outer surface extending towards tip, raised area forming distinct ridge; lobe less than 1.7 mm. wide (fig. 8). (19) Hairs long, longest hairs of face about two-thirds as long as scape. (20) Anterior margin of genal area, along eye, with short, appressed, plumose hair. (26) Longest hairs of tergum two twice as long as lateral width of colored bands.

Female. (37) Scutellum slightly depressed in center. (40) Tegula straight on outer edge. (45) Hairs long, longest hairs of face longer than distance from antenna to inner eye margin. (46) Anterior margin of genal area, along eye, with short, appressed, plumose hair. (48) Median mesoscutal line obscured anteriorly by long hairs.

Variation. This subspecies exhibits little interpopulational variation in Mexico. It may intergrade with *n. nortoni* in northeastern Mexico or in north central Mexico. Evidence for the latter possibility is the males from southern Arizona that have short body hair like *n. nortoni* and an intermediate hair condition on the genal area,

but have the hind tibia as in *n. cressoni.* The females from Arizona also have body hair like *n. nortoni,* but have a genal hair condition like *cressoni.*

TYPE MATERIAL. Westwood in his original description cites a male from Mexico (D. Coffin) labeled Hym. No. 96. He also mentions the female. The male is in the Oxford Museum collection together with a female labeled Mexico (D. Coffin). This female specimen seems to be a syntype. It is not known whether Westwood also had other specimens when he described *cressoni.* I now designate this male as the lectotype for *cressoni.* Dr. M. W. R. de V. Graham compared this specimen with my description of *n. cressoni* and with a specimen from San Juan de los Lagos and reports agreement.

RANGE. This subspecies is found on the Mexican plateau, above 5,000 feet, from Mexico City to Durango, with possible intergrades in southern Arizona (map 4).

LIST OF LOCALITIES. ARIZONA (intergrades toward *n. nortoni;* see discussion above). Santa Cruz Co.: Madera Canyon (Santa Rita Mountains) ♂, Patagonia 2♂, Peña Blanca Lake (5.5 mi. W.) 6♀, Ruby 2♀2♂, Sycamore Canyon (near Ruby) 7♀13♂. MÉXICO. Distrito Federal 2♀♂: Guadalupe ♀, Mexico City 3♀4♂; Durango: Coyotes ♀, El Salto (6 mi. N. E.) ♂, Palos Colorados ♀; Guanajuato: Jural ♂; Jalisco: Guadalajara 2♀2♂, Lagos de Moreno (15 mi. N. E.) ♂, La Piedad ♂, Ojuelos ♀, San Juan de los Lagos 5♀13♂, Villa Guadalupe ♀2♂; México: Texcoco; * Michoacán: Lake Pátzcuaro 9♀; Puebla: Puebla (28 mi. W.) ♀; Zacatecas: Fresnillo (9 mi. S.) ♀.

FLOWER RECORDS. ASCLEPIADACEAE: *Asclepias* sp. ♀2♂. LABIATAE: *Stachys Bigelovii* ♀. LEGUMINOSAE: *Eysenhardtia polystachys* 2♀5♂.

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults.

Nomia (*Acunomia*) *melanderi* Cockerell

This species of *Acunomia* is similar to *nortoni,* but is much smaller. It can be distinguished from any other North American bee, except *robinsoni,* by its size, integumental colored abdominal bands, long pointed antennae in the male and the coarse irregular teeth near the apex of the middle tibial spur in the female. From *robinsoni* it can be told by the lack of a carina on the pronotum.

Male. *Structure:* (1) Mandible with large toothlike lobe on posterior margin. (2) Clypeus with bare part impunctate or with few fine, scattered punctures; bare part flat or slightly depressed in center or with weak longitudinal carina; subapical area slightly depressed or flat. (3) Last flagellar segment acutely pointed, one and one-half times as long as second flagellar segment. (4) Pronotum without carina on posterior, dorsal edge. (5) Scutellum slightly depressed in center, lateral higher parts less densely punctate than surrounding area. (6) Metepisternum coarsely to finely wrinkled. (7) Propodeum with anterior groove slightly widened medially. (8) Tegula straight on outer edge, rounded posteriorly. (9) Front wing length (see section on methods) about 8.0 mm. (range: 7.0-9.6). (10) Middle tibial spur straight. (11) Posterior femur twice as long as broad, large basal and lateral areas nearly impunctate and shining. (12) Posterior tibia produced anteriorly and distally into large rounded lobe which hides tibial spurs in side view (fig. 9). (13) Metasomal tergum 1 coarsely punctate except for band of minute punctures at base of apical, depressed, hyaline portion; median width of band varies from two to four rows of punctures, width of band reduced laterally. (14) Terga 2 to 4 with few coarse punctures like those of tergum 1 on raised part of postgradular area; otherwise with small, close punctures except on colored bands. (15) Sternum 3 with ventrolateral, toothlike process three to four times as wide as high. (16) Ventroapical median part of gonobase forming rounded projection. (17) Penis valve with small oblong ventral opening; valve produced laterally into rounded projection; tip slender and pointed (fig. 31). *Pubescence:* (18) Face, including upper half of clypeus and lateral part of scape, covered with short, appressed, plumose, white hairs. (19) Longest hairs of face half to two-third as long as scape. (20) Anterior margin of genal area, along eye, with short, appressed, plumose hairs. (21) Hair of anterior part of mesoscutum, of posterior lobe of pronotum, and of anterior part of mesepisternum yellow-white to white. (22) Median mesoscutal line and notaulus obscured by hairs or visible posteriorly. (23) Metanotum with anterior fourth to half obscured by short, plumose hairs. (24) Tegula covered with plumose hairs posteriorly. (25) Propodeal hairs white. (26) Longest hairs of tergum 2 as long as to twice as long as lateral width of colored band. (27) Terga 2 to 4 with hairs all white. *Color:* (28) Mandible black or translucent

red-brown, with subapical red area. (29) Flagellum yellow to orange below. (30) Legs black to red-brown, except metabasitarsus below, other tarsal segments, and underside and apices of tibiae, which may be yellow. (31) Stigma usually dark brown, darker than most wing veins; vein R, intersection of M and Cu, and distal end of V dark brown to black. (32) Terga 2 to 5 and sometimes 1 with apical colored bands; band of tergum 5 present laterally; band color variable, blue, green, white or yellow with pink, gold, purple or red iridescence.

FEMALE. *Structure:* (33) Clypeal margin truncate to emarginate medially; part overhanging base of labrum hyaline or not; longitudinal carina very weak; clypeus evenly punctate or punctures weaker and further apart on central elevated portion. (34) Face with elevated portion below antennae impunctate or with few punctures. (35) Pronotum without carina on posterior, dorsal edge. (36) Mesoscutum and scutellum with large bare nearly impunctate areas; scutellum flat in center. (37) Mesepisternum with medium to coarse wrinkles. (38) Propodeum with anterior groove sometimes widened medially. (39) Tegula straight on outer edge, rounded posteriorly. (40) Front wing length (see section on methods) about 7.2 mm. (range 6.2-8.4). (41) Metasomal tergum 1 with small punctures at sides, becoming smaller and more scattered towards center except band of minute punctures at base of apical, depressed, hyaline portion; median width of band half width of hyaline portion. (42) Tergum 2 with small punctures at sides of basal area, becoming much finer toward center or not becoming finer toward center. (43) Tergum 3 with gradular ridge distinct and with few scattered punctures. *Pubescence:* (44) Longest hairs of face about as long as distance from antenna to inner eye margin. (45) Anterior margin of genal area, along eye, with short, appressed, plumose hairs. (46) Mesoscutal hairs all white to mostly dark. (47) Notaulus visible or obscured; median mesoscutal line visible or obscured anteriorly by long hairs. (48) Metanotum completely to its anterior half obscured by short, plumose hairs; no longer black hairs present. (49) Tegula covered with plumose hair posteriorly. (50) Tergum 1 with lateral part of depressed, hyaline, portion partly obscured by subappressed mat of hairs. (51) Terga 2 and 3 with hair all white, tergum 4 with or without some black hairs. *Color:* (52) Antennae light brown to orange-brown below. (53) Stigma black, darker than most veins; vein R, intersection of M and Cu, and distal end of

V black to dark brown. (54) Legs dark brown. (55) Terga 1 to 5 with apical colored bands, sometimes indistinct on tergum 1; band color variable, yellow, white or green with purple, pink, yellow, orange or red iridescence.

Nomia (*Acunomia*) *melanderi melanderi* Cockerell

(Figs. 9, 25, 27-29 and 31; Map 4; Tables 4 and 5)

Nomia melandri Cockerell, 1906b, p. 279 (*lapsus calami*) (tax., ♀); Tysdal, 1940, p. 583 (alf.); Linsley and MacSwain, 1947b, p. 354 (alf.); Michener, 1954, p. 68 (pupa).

Nomia melanderi: Cockerell, 1908, p. 334 (justified emendation of *N. melandri* Cockerell) (tax., ♀); Cockerell, 1925a, p. 188 (tax.); Cockerell, 1930, p. 12 (tax.); Linsley, 1946, p. 19 (alf.); Vansell and Todd, 1946, p. 473 (alf.); Bohart, 1947, p. 13 (biol.); Linsley and MacSwain, 1947b, p. 352 (alf.); Bohart, 1948, p. 58 (alf.); Annand, 1949, p. 49 (biol.); Bohart and Lieberman, 1949a, p. 519 (alf.); Bohart and Lieberman, 1949b, p. 1 (alf.); Anonymous, 1950, p. 212 (alf.); Bohart, Knowlton and Bailey, 1950, p. 4 (rec.); Bohart, Knowlton, Nye and Todd, 1950, p. 66 (biol.); Hoyt, 1950, p. 58 (alf.); Linsley, MacSwain and Smith, 1950, p. 61 (alf.); Bohart, 1951, p. 32 (biol.); Hoyt, 1951, p. 61 (alf.); Menke, 1951, p. 624 (alf.); Bohart, 1952, p. 110 (biol.); Menke, 1952a, p. 16 (biol.); Menke, 1952b, p. 334 (alf.); Anonymous, 1953, p. 21 (biol.); Menke, 1953, p. 15 (alf.); Menke, 1954a, p. 539 (alf.); Menke, 1954b, p. 1 (alf.); Stevens, 1954, p. 33 (alf.); Bohart, 1955b, p. 23 (biol.); Bohart and Cross, 1955, p. 403 (biol.); Bohart, Nye and Levin, 1955, p. 51 (biol.); Bohart and Nye, 1956a, p. 332 (alf.); Bohart and Nye, 1956b, p. 468 (biol.); Bohart, 1957b, p. 359 (alf.); Bohart and Nye, 1957, p. 83 (biol.); Frick, 1957, p. 503 (para.); Todd, 1957, p. 66 (biol.); Bohart, 1958a, p. 94 (biol.); Bohart, 1958b, pp. 931 and 935 (biol.); Cross, 1958b, p. 135 (biol.); Linsley, 1958, pp. 551-554, 556, 566, 581-584 (biol.); Anonymous, 1959a, p. 150 (para.); Stephen, 1959a, p. 3 (biol.); Bohart, 1960a, p. 75 (alf.); Bohart, 1960b, pp. 59 and 64 (alf.); Bohart and Nye, 1960, p. 12 (fls.); Bohart, Stephen and Eppley, 1960, p. 425 (para.); Frick, Potter and Weaver, 1960, p. 1 (biol.); Fronk and Painter, 1960, p. 424 (biol.); Howell, 1960, p. 679 (biol.); Laffoon, 1960, pp. 176 and 202 (tax.); Stephen, 1960a, p. 15 (biol.); Stephen, 1960b, p. 27 (biol.); Stephen, 1960c, p. 1025 (biol.); Stephen and Evans, 1960, p. 3 (biol.); Frick, 1962, p. 5 (para.).

Nomia (*Paranomia*) *melanderi:* Cockerell, 1910b, p. 296 (tax.).

Nomia (*Paranomia*) *californica* Cockerell, 1910b, p. 296 (tax., ♀).

Nomia (*Paranomia*) *acus* Cockerell, 1910b, p. 296 (tax., ♂).

Nomia acus: Cockerell, 1923, p. 102 (tax.); Cockerell, 1930, p. 12 (tax.); Bohart, Knowlton and Bailey, 1950, p. 4 (rec.).

Nomia californica: Cockerell, 1924, p. 541 (tax.); Cockerell, 1925a, p. 188 (in part) (tax.); Blair, 1930, pp. 7 and 17 (tax.); Cockerell, 1930, p. 12 (tax.); Cockerell, 1933, p. 159 (rec.); Cockerell, 1934a, p. 21 (rec.); Michener, 1936, p. 4 (rec.); Michener, 1937, p. 318 (tax.); Bohart, Knowlton and Bailey, 1950, p. 4 (rec.).

Nomia melanderi acus: Cockerell, 1925a, p. 188 (tax.).

Nomia melanderi paysoni Cockerell, 1925c, p. 621 (tax., ♂); Cockerell, 1928, p. 101 (rec.).

Nomia californica var. *paysoni:* Cockerell, 1930, p. 12 (tax.).

Nomia (*Acunomia*) *melanderi:* Bohart, 1950, p. 32 (biol.); Cross, 1958a, p. 1265 (tax.); Cross and Bohart, 1960, p. 761 (biol.); Hirashima, 1961, pp. 294 and 300 (biol.).

Nomia (*Acunomia*) *melandri melandri:* Michener, 1951, p. 1128 (cat.).

Nomia (*Acunomia*) *melandri:* Michener, 1953, p. 1030 (larva).

Nomia melanderi melanderi: Selander and Bohart, 1954, p. 228 (biol.).

Nomia (*Acunomia*) *melanderi melanderi:* Krombein, 1958, p. 103 (para.).

Alkali bee, Aicher, 1917, p. 5 (alf.); Knowles, 1943, p. 29 (alf.); Tysdal, 1946, p. 531 (alf.); Vansell and Todd, 1947, p. 137 (alf.); Bohart, 1952, p. 1 (biol.); Hoyt, 1952, p. 49 (alf.); Knowlton, 1952, p. 2 (alf.); Vansell and Griggs, 1952, p. 90 (fls.); Tonz, 1954, p. 418 (alf.); Bohart, 1955a, p. 26 (alf.); Bohart and Nye, 1956c, p. 605, (biol).; Bohart, 1957a, p. 33 (alf.); Robb, 1957, p. 3 (alf.); Wheeler and Hill, 1957, p. 333 (alf.); Anonymous, 1958, p. 8 (biol.); Anonymous, 1959b, p. 12 (biol.); Nye and Bohart, 1959, p. 140 (para.); Stephen, 1959b, p. 69 (biol.); Anonymous, 1960a, p. 38 (alf.); Anonymous, 1960b, p. 14 (biol.); Bohart and Knowlton, 1960, p. 1 (biol.); Doull and Purdie, 1960, photos on p. 17 (biol.); Morse, 1960, p. 7 (biol.); Stephen, 1960d, p. 30 (biol.); Anonymous, 1961, p. 4 (biol.); Bohart and Todd, 1961, p. 242 (alf.); Stephen and Torchio, 1961, p. 89 (biol.); Todd and McGregor, 1961, pp. 249 and 368 (alf.).

This subspecies is commonly referred to as the alkali bee (Laffoon, 1960); therefore references using only this name are cited above under that name.

The alkali bee has been introduced by means of artificial bee "beds" into several areas where it does not occur or where it occurs in small numbers. These introductions will present problems for future students studying the geographical variation of this bee.

In Cockerell's original description the spelling *melandri* is used for this species. The label attached to the holotype also has this spelling. Cockerell stated he received the holotype from A. L. Melander from which one can judge that his spelling of the specific name was a lapsus. Thereafter Cockerell himself used the spelling *melanderi;* his 1908 publication can be considered as a justified emendation of the name *melandri.* This subspecies has gone under several other names, as shown above, due in part to the great differences between the sexes and its wide range.

Male. (9) Front wing length (see section on methods) about 8.5 mm. (range: 7.5-10.5). (12) Hind tibial lobe usually squared on anterodistal margin (fig. 9). (19) Hairs long, longest hairs of face about two-thirds as long as scape. (22) Median mesoscutal line and notaulus obscured by hairs. (26) Longest hairs of tergum 2 about twice as long as lateral width of colored band. (32) Colored band of tergum 1 usually absent, sometimes present at sides or complete but narrowed in center, or occasionally broad as in *m. howardi.*

Female. (42) Tergum 2 with small punctures at sides of basal area, punctures becoming finer towards center. (46) Mesoscutal hairs mostly dark, sometimes all white. (47) Hairs long, notaulus obscured, median mesoscutal lines obscured anteriorly by hairs. (55) Tergum 1 with apical colored band, sometimes indistinct; band one-third width of band of tergum 2; band on tergum 2 0.66 mm. wide.

Variation. Like *N. n. nortoni,* this wide ranging subspecies exhibits little interpopulational variation in the characters studied. A specimen collected in Idaho could not be distinguished from one collected in southern California. However, this subspecies exhibits much more intrapopulational variation than *n. nortoni.* All the characters that separate *m. howardi* from *m. melanderi* are occasionally found among individuals of *m. melanderi,* but individuals with

these characters occur at random throughout the range of *m. melanderi,* and single specimens do not show more than one or possibly two characters of the other subspecies. This variation does not seem to be clinal in nature. Some of the specimens from the Hemet-La Quinta area (a and b respectively on map 4) in southern California are an exception to the above. Those from Hemet agree with *m. melanderi* in most characters, but tend toward *m. howardi* in hair pattern.[1] The female from La Quinta mostly closely resembles *m. melanderi,* except in hair length, in which it agrees more closely with *m. howardi.* The male from the same locality is a typical *m. howardi.* La Quinta is 38 miles from Hemet.

TYPE MATERIAL. The female holotype of *melanderi,* N. Yakima, Washington, July 10, 1903, Yakima Expedition (from A. L. Melander), is in the collection of the Citrus Experiment Station, Riverside, California. The female holotype of *californica,* Los Angeles Co., California (D. W. Coquillett), is at the U. S. National Museum, type number 12986. The male holotype of *acus,* southern California (C. V. Riley), is also in the U. S. National Museum, type number 12987. The male holotype of *melanderi paysoni,* Naturita, Colorado, June 27, 1924 (Edwin Payson), is at the Citrus Experiment Station.

RANGE. This subspecies ranges from central Washington to southern California and east to Wyoming, where it is replaced by the similar but larger eastern species, *N. nortoni.* To the south *m. melanderi* is replaced by the desert form, *m. howardi* (map 4). I have seen four specimens of *m. melanderi* labeled Sedan, Minnesota. If these specimens are labeled correctly it seems strange that no specimens of this subspecies have been collected in South Dakota.

LIST OF LOCALITIES. CALIFORNIA. Colusa Co.: Colusa 6 ♀ 22 ♂; Contra Costa Co.: Antioch 14 ♀ 9 ♂; Fresno Co. ♀ 2 ♂: Dos Palos (5 mi. S.) ♀, (5 mi. E.) 4 ♂, (7 mi. E.) ♀ 14 ♂, Firebaugh ♀ 7 ♂, (1 mi. S.) 3 ♀, (2 mi. W.) ♀, (4 mi. N. W.) 3 ♂, (7 mi. S.) 2 ♀ 3 ♂, Kerman (8 mi. W.) ♀, Mendota 2 ♀ 6 ♂, Oxalis 2 ♀, Rasin 2 ♀, Tranquillity 2 ♂; Glenn Co.: Artois ♀; Inyo Co.: Bigpine 2 ♀ ♂, Bishop ♀ ♂, Lone Pine (2 mi. N.) ♂, (3 mi. N.) ♀ ♂; Kern Co.: McFarland ♀, Shafter ♀; Kings Co.: Lemoore (8 mi. S. W.) ♀,

1. Six other females in the University of California collection are typical *m. howardi* although, labeled as from Hemet. As all were taken on a single day, and as collections of *howardi* were being made at about the same time by the same collector in Blythe it seems probable that the specimens of *howardi* from Hemet were mislabeled. If not, the two forms exist together at Hemet and a case might be made for regarding them as distinct species.

Stratford (4 mi. N. W.) 5 ♀; Lassen Co.: Hallelujah Junction ♀, Wendel ♀; Los Angeles Co. 2 ♀; Merced Co.: Dos Palos 16 ♀ 22 ♂, El Nido (4 mi. S. E.) ♂, Los Banos ♂, Merced ♀, Turlock (10 mi. S. W.) ♀; Napa Co.: St. Helena ♀ ♂; Riverside Co.: Hemet 75 ♀ 74 ♂, (10 mi. W.) 4 ♀, Riverside 68 ♀ 40 ♂, Riverside (Fairmont Lake?) 8 ♂, Romoland ♂; Sacramento Co.: Sacramento 7 ♂, Sherman Island ♀; San Joaquin Co.: Tracy 3 ♀ 20 ♂, (6 mi. N. W.) ♀ 2 ♂; Santa Clara Co.: Milpitas (Dixon Road) 85 ♀ 60 ♂; Siskiyou Co.: Gazelle 2 ♀ 2 ♂, Lower Klamath Lake ♂; Solano Co.: Rio Vista ♀; Stanislaus Co.: Newman ♀, Patterson ♂, San Joaquin River (10 mi. S. W. Turlock) ♀, Turlock 15 ♀ 40 ♂, Westley 2 ♀ ♂; Tulare Co.: Angiola ♀; Yolo Co.: Davis ♀ 3 ♂, Winters (Putah Creek) ♂, Woodland 2 ♀ 2 ♂; Yuba Co.: Marysville ♀ 7 ♂; County ?: San Francisco Bay (Salt Marshes) 5 ♀ 2 ♂. COLORADO. Delta Co.: Delta 5 ♀ 17 ♂, Hotchkiss ♀; Eagle Co.: Gypsum 7 ♂; Garfield Co.: Glenwood Springs 2 ♀, Rifle 6 ♀ 3 ♂; Mesa Co.: Fruita 5 ♀ ♂, Grand Junction 29 ♀ 9 ♂, Palisade 4 ♀ 2 ♂; Montrose Co.: Naturita ♂. IDAHO. Ada Co.: Boise (7 mi. S. E.) 5 ♀ ♂; Bear Lake Co.: Paris ♀; Bingham Co.: Aberdeen 13 ♀ 8 ♂, (5 mi. N.) 11 ♀ 12 ♂, (4 mi. E.) ♀, Fort Hall ♀ 2 ♂, Mill Creek (near Blackfoot) 2 ♀, Springfield ♀ ♂, Sterling (3 mi. W.) 8 ♀ 20 ♂; Butte Co.: Howe (11 mi. N.) 4 ♂; Canyon Co.: Melba (8 mi. N.) ♀, (2 mi. N.) ♀ ♂, Parma 2 ♂; Franklin Co.: Preston 16 ♀; Gooding Co.: Bliss 7 ♀ ♂, Tuttle ♀ 2 ♂, Wendell ♀; Jerome Co.: Eden 2 ♀ 2 ♂, Hazelton (5 mi. S.) ♀, (3 mi. N. E.) 20 ♀, (4 mi. N.) 3 ♀, (7 mi. N.) 3 ♀ ♂, Jerome 7 ♀ 3 ♂, (7 mi. S.) ♀; Latah Co.: Moscow ♀; Madison Co.: Rexburg 7 ♀; Owyhee Co.: Grand View 2 ♀, Marsing (3 mi. S. W.) ♀, Murphy? Hot Springs 2 ♂; Payette Co.: Fruitland ♂, Payette 4 ♂; Power Co.: American Falls ♀; Twin Falls Co.: Buhl 2 ♀ ♂, Castleford ♂, Clover 26 ♀ 5 ♂, Filer ♂, Hansen ♂, Hollister 2 ♂, Kimberly 15 ♀ 5 ♂, Twin Falls 12 ♀ 8 ♂; County ?: Blue Lakes (Snake River Canyon) 2 ♂. MINNESOTA. Pope Co.: Sedan ♀ 3 ♂. MONTANA. Sanders Co.: Weeksville ♂. NEVADA. Humboldt Co.: Paradise Valley ♂; Lincoln Co.: Panaca 2 ♀; Washoe Co.: Pyramid Lake 9 ♀ 9 ♂. OREGON. Deschutes Co.: Bend,* Redmond ♀ 5 ♂; Gilliam Co.: Arlington 2 ♀ 2 ♂; Jefferson Co.: Madras 5 ♀ 3 ♂; Klamath Co.: Henley ♀; Malheur Co.: Adrian 2 ♀, (8 mi. S.) ♂, (6 mi. S.) 11 ♀ ♂, (5 mi. N. W.) ♀ 2 ♂, Juntura (13 mi. S.) ♂, Nyssa (Klamath Ave.) 2 ♀, (10 mi. S. W.) ♀, Ontario ♂, Vale ♀ 2 ♂, (West of) 2 ♀; Umatilla Co.: Hermiston ♂,

Milton,* Umatilla 5 ♂; Union Co.: Hot Lake 3 ♀ 6 ♂, La Grande 2 ♀, North Powder 3 ♀ 3 ♂; Wasco Co.: The Dalles.* UTAH. Beaver Co. ♀ 2 ♂; Box Elder Co.: Brigham City ♀, Garland ♂, Tremonton (10 mi. S. W.) 4 ♀ 2 ♂; Cache Co.: Ballard Junction ♀ 2 ♂, Logan 19 ♀ 13 ♂, Mendon ♂, Newton ♀ ♂, Petersboro,* Smithfield 8 ♀ ♂; Carbon Co.: Pleasant Valley (near Scofield) ♀ ♂, Price 5 ♀ 6 ♂; Duchesne Co.: Bluebell 7 ♀ ♂, Myton 18 ♀ 4 ♂, Roosevelt ♀ 3 ♂; Emery Co. ♀ 32 ♂: Castle Dale 2 ♀ 24 ♂; Iron Co.: Iron Springs ♀ ♂, Little Salt Lake ♂, Parowan 5 ♂; Juab Co.: Trout Creek ♀; Kane Co.: Orderville 2 ♂, Esclante Desert (Willow Tank?) ♂; Millard Co. 2 ♀: Delta 33 ♀ 61 ♂, Fillmore 2 ♀, Flowell 2 ♂, Gandy 3 ♀, Leamington 4 ♂, Lynndyl 2 ♂, (sand dunes N.) ♀ 5 ♂, Pahvant 26 ♂, Sutherland 5 ♀ ♂, Topaz ♀ 4 ♂; Piute Co.: Circleville 3 ♀ 2 ♂; Rich Co.: Bear Lake Valley (west side) 7 ♀; Salt Lake Co.: Salt Lake City 2 ♀ 2 ♂; Tooele Co.: Iosepa ♀, St. John ♂; Uintah Co.: Jensen ♂, Randlett 5 ♂, Vernal 5 ♀; Utah Co.: Provo 3 ♀ 2 ♂, Thistle 2 ♀, Utah Lake (west side) ♂, (east side) ♂; Washington Co.: Pintura ♀, St. George 3 ♀ ♂; Weber Co.: Ogden ♂. WASHINGTON. Adams Co.: Othello;* Benton Co. ♀: Prosser 2 ♀ ♂; Franklin Co.: Scootenary Reservoir;* Grant Co.: Moses Lake 3 ♀, Quincy ♀, Soap Lake;* Walla Walla Co.: Gardena 5 ♀ 4 ♂; Whitman Co.: Pullman ♂; Yakima Co.: Harrah 3 ♀, Wapato 2 ♀, Yakima 2 ♀ 2 ♂. WYOMING. Big Horn Co. (north) 4 ♀ 3 ♂: Greybull ♂; Campbell Co. ♂; Fremont Co.: Lander (15 mi. S.) ♀, Pavillion 3 ♀, Riverton 16 ♀ ♂, Shoshoni 3 ♀ 4 ♂; Park Co.: Powell 2 ♀ 3 ♂; Sweetwater Co.: Granger 6 ♀ 2 ♂, Green River ♀ 3 ♂; Teton Co.: Grand Teton National Park ♀ 3 ♂; Yellowstone National Park 3 ♀ 3 ♂: (Dunraven Pass) ♂, (Tower Falls) ♀ ♂, (Old Faithful) ♂.

FLOWER RECORDS. ASCLEPIADACEAE: *Asclepias* sp. 5 ♀ 5 ♂, *A. speciosa* ♂, *A. subverticillata* ♀. BORAGINACEAE: *Helitropium* sp. ♀ 3 ♂, *H. curassavicum* 4 ♀ ♂. CAPPARIDACEAE: *Cleome* sp. 3 ♀ 4 ♂, *C. lutea* ♀ ♂, *C. serrulata* 14 ♀ 29 ♂. CHENOPODIACEAE: *Beta vulgaris* 3 ♀ 10 ♂, *Salsola Kali* ♂. COMPOSITAE: *Aster* sp. 7 ♀, *Baccharis emoryi* 2 ♀, *Centromadia pungens* 2 ♀ 5 ♂, *Chrysothamnus*, 2 ♀ 4 ♂, *C. nauseosus*,* *Cirsium* sp. 2 ♀, *Coreopsis* sp. ♀, *Crepis glauca*,* *Erigeron* sp. ♂, *Grindelia* sp. 3 ♀, *Haplopappus* sp. ♀, *H. venetus* ♀, *Helianthus* sp. 2 ♀ 4 ♂, *Isocoma veneta* ♂, *Pluchea camphorata* 6 ♀ 5 ♂, *P. sericea* 7 ♀, *Solidago* sp. 3 ♀ 9 ♂, *S. occidentalis* 2 ♀. CONVOLVULACEAE: *Convolvulus arvensis*,* *Cressa cretica* ♂, *Cuscuta* sp.,* *C. salina.** CRUCIFERAE: *Brassica* sp. 3 ♀, *B. geniculata* ♀, *Sisymbrium altissimum* ♀, *Wislizenia*

refracta 3 ♀. CUCURBITACEAE: *Citrullus vulgaris* 2 ♀ 3 ♂. DIPSACACEAE: *Dipsacus.** EUPHORBIACEAE: *Croton californicus* 4 ♂, *Eremocarpus setigerus* ♀. LABIATAE: *Mentha* sp. ♀, *M. spicata.** LEGUMINOSAE: *Astragalus* sp. ♀, *Lotus* sp. 3 ♀ 3 ♂, *L. purshianus* ♀ 14 ♂, *Medicago* sp. ♀, *M. sativa* 56 ♀ 22 ♂, *Melilotus* sp. 17 ♀ 40 ♂, *M. alba* 6 ♀ 6 ♂, *M. indica,** *Trifolium* sp. ♂, *T. hybridum* ♀, *T. pratensa* ♀, *T. repens* ♀. LILIACEAE: *Allium* sp.* MALVACEAE: *Gossypium* sp. ♀. PAPAVERACEAE: *Eschscholtzia californica* 2 ♀. POLYGONACEAE: *Eriogonum* sp. 13 ♀ ♂, *Polygonum lapathifolium* ♀ 13 ♂. SOLANACEAE: *Solanum tuberosum* ♀ ♂, *S. elaeagnifolium* ♀. TAMARICACEAE: *Tamarix gallica* 2 ♀ 4 ♂. UMBELLIFERAE: *Apium graveolens* ♂, *Berula erecta* ♂, *Daucus carota* 5 ♀ ♂. VERBENACEAE: *Lippia lanceolata* 5 ♀. ZYGOPHYLLACEAE: *Tribulus* sp. 2 ♂.

As shown above, *m. melanderi* is found on a wide variety of flowers. Bohart and Nye (1956c) say they have found as many as six different types of pollen on the legs of a single bee. For more information on floral preferences see Selandar and Bohart (1954) and Stephen (1959a). The data above are summarized in table 4.

PARASITES, PREDATORS AND DISEASES. In the list below the life stage that is attached is shown in brackets. Only the first citation in the literature is given.

Bacteria [larva and prepupa], Stephen, 1959a.

Aspergillus ustus (fungus) [prepupa], Stephen, 1959a.

A. terreus (fungus) [prepupa], Stephen, 1959a.

Imparipes americanus (Acarina: Scutacaridae) [adult], determined by Dr. E. A. Cross.

Mites [larva and prepupa], Stephen, 1959a.

Cicindela haemorrhagica (Coleoptera: Cicindelidae) [adult], Frick, 1957.

C. pusilla (Coleoptrea: Cicindelidae) [adult], Frick, 1957.

Nemognatha sp. (Coleoptera: Meloidae) [egg and pollen ball], Bohart, 1950.

Zonitis atripennis (Coleoptera: Meloidae) [egg and pollen ball], Selander and Bohart, 1954.

Hetrostylum robustum (Diptera: Bombyliidae) [larva], Bohart, 1950.

Erax stramineus (Diptera: Asilidae) [adult], Frick, 1962.

Phoridae (Diptera) [egg and pollen ball], Bohart, 1950.

Zodiom obliquefasciatum (Diptera: Conopidae) [adult], Bohart, 1950.

Otitidae (Diptera) [pollen ball], Bohart, 1950.

TABLE 4.—Summary of Flower Records for *Nomia melanderi melanderi* Cockerell

Plant Data*			Records of *N. m. melanderi*			
FAMILY	Number of genera	Number of species	Number of collections	Number of females	Number of males	Total number of bees
Asclepiadaceae	1	2	7	6	6	12
Boraginaceae	1	1	6	5	4	9
Capparidaceae	1	2	10	18	34	52
Chenopodiaceae	2	2	11	3	11	14
Compositae	14	15	36	47	32	79
Convolvulaceae	3	3	1	0	1	1
Cruciferae	3	3	7	8	0	8
Cucurbitaceae	1	1	2	2	3	5
Dipsacaceae	1	1	0	0	0	0
Euphorbiaceae	2	2	2	1	4	5
Labiatae	1	1	1	1	0	1
Leguminosae	6	8	60	88	86	174
Liliaceae	1	1	0	0	0	0
Malvaceae	1	1	1	1	0	1
Papaveraceae	1	1	2	2	0	2
Polygonaceae	2	2	9	15	14	29
Solanaceae	1	2	3	2	1	3
Tamaricaceae	1	1	2	2	4	6
Umbelliferae	3	3	6	5	3	8
Verbenaceae	1	1	2	5	0	5
Zygophyllaceae	1	1	1	0	2	2
Total	48	54	169	211	205	416

* Records from the literature are included under this heading.

Sarcophagidae (Diptera) [pollen ball], Bohart, 1950.

Dasymutilla vesta (Hymenoptera: Mutillidae) [?], Krombein, 1958.

Pseudomethoca propinqua (Hymenoptera: Mutillidae) [?], Krombein, 1958.

Formica fusca (Hymenoptera: Formicidae) [adult], Frick, 1962.

Nomada suavis (Hymenoptera: Apidae) [pollen ball], Bohart, 1950.

Skunk (Carnivora: Mustelidae) [prepupa], Anonymous, 1958.

Mus musculus (Rodentia: Muridae) [prepupa], Frick, 1962.

Microtus sp. (Rodentia: Cricetidae) [prepupa], Frick, 1962.

Birds [adult]: blackbirds, Anonymous, 1953; English sparrow, Stephen, 1959a; magpie, Stephen, 1959a; meadowlark, Stephen, 1959a; robin, Frick, 1962; lark, Frick, 1962.

Dr. G. E. Bohart has kindly supplied the following unpublished biological information on *Euphytomima nomiivora* James (1955) (Diptera: Sarcophagidae), a parasite of *Nomia melanderi, Nomadopsis anthidius* and *N. scutellaris.* It is found in northern Utah and extreme southern Idaho, where it seems to be a serious parasite of *melanderi.* It lays eggs and first-instar larvae in the lip of the burrow. The larvae probably are carried down to the cells by the bee. They rupture the egg of the bee and then feed on the pollen ball. The mature maggots migrate several inches away from the bee cell to pupate.

BIOLOGY. Since this subspecies is an important pollinator of alfalfa much has been written about its biology, the most important works being by Bohart, Stephen, Frick and Menke.

SEASONAL ACTIVITY. Table 5 gives the seasonal distribution of collection dates on the specimens examined. This range consider-

TABLE 5.—Seasonal Activity and Number of Specimens Examined of *Acunomia* and *Curvinomia*

SPECIES	Earliest date collected		Latest date collected		Total number of bees examined
	Month	Day	Month	Day	
N. maneei	V	14	IX	1	105
N. fedorensis	V	11	VII	17	56
N. universitatis	V	2	VIII	16	110
N. angustitibialis	VIII	1	IX	27	62
N. foxii	VI	15	X	24	898
N. t. tetrazonata	III	25	X	28	651
N. t. uvaldensis	III	20	VIII	25	119
N. n. nortoni	IV	1	X	19	743
N. n. cressoni	VII	9	IX	1	89
N. m. melanderi	IV	15	XI	6	1,599
N. m. howardi	IV	6	IX	28	297
*N. robinsoni**	VI	9	X	11	50
Total					4,779

* Cuba only.

ably exceeds the length of seasonal activity given in the literature. Below are some samples of seasonal activity as described by various authors studying the biology of this bee:

Washington; late May and mid-June to August (Frick, Potter and Weaver, 1960).

Oregon; late June to September 6, 1957 (Stephen, 1959), last week of May to August 26, 1958 (Stephen, 1959).

Utah, Idaho and Wyoming; about July 1 for male and middle to late July for females to early September (Bohart, Nye and Levin, 1955).

Stephen (1959) and Bohart, Nye and Levin (1955) state that the males emerge slightly before the females, and Stephen shows variation in emergence during different years. Stephen says there is but one brood a year in Oregon, while Bohart, Nye and Levin say there is a partial second generation in Utah. It is not surprising that in examining specimens collected over a number of years in different localities, there is an extension of the dates of adult activity beyond those recorded in a limited area in a short time. The extremes in table 5 are represented by few specimens. The earliest date is from Utah and the latest is from Washington.

Nomia (*Acunomia*) *melanderi howardi* Crawford, new combination

(Fig. 10; Map 4; Table 5)

Nomia howardi Crawford, 1911, p. 617 (tax., ♀); Cockerell, 1923, p. 103 (rec.); Cockerell, 1924, p. 541 (tax.); Cockerell, 1930, p. 14 (tax.).

Nomia californica: Cockerell, 1923, p. 102 (tax.); Cockerell, 1925a, p. 188 (in part) (tax.).

Nomia howardi vanduzeei Cockerell, 1924, p. 540 (tax., ♀); Cockerell, 1930, p. 14 (tax.), new synonymy.

Nomia californica peninsularis Cockerell, 1930, p. 12 (tax.), new synonymy.

Nomia peninsularis: Linsley, 1946, p. 20 (biol.); Linsley and MacSwain, 1947a, p. 362 (alf.); Linsley and MacSwain, 1947b, p. 352 (alf.); Bohart and Lieberman, 1949a, p. 519 (alf.); Bohart and Lieberman, 1949b, p. 1 (alf.); Linsley, MacSwain and Smith, 1950, p. 59 (alf.).

Nomia (*Acunomia*) *melanderi peninsularis:* Michener, 1951, p. 1128 (cat.).

Nomia melanderi: Butler, 1955, p. 2 (biol.).

This subspecies has gone under several names, as shown above, due in part to the great difference between the sexes, and to Cockerell's seeming failure to examine the type of *howardi*. *N. m. howardi* is different in several ways from the typical *m. melanderi*, as shown below, and occupies a different habitat. It seems best to regard *howardi* as a subspecies of *melanderi* at this time (see discussion under *melanderi* proper).

Male. (9) Front wing length (see section on methods) 7.5 mm. (range: 7.0-7.9). (12) Hind tibial lobe usually rounded on anterodistal margin (fig. 10). (19) Hairs short, longest hairs of face about half as long as scape. (22) Median mesoscutal line and notaulus not obscured by hairs posteriorly. (26) Longest hairs of tergum 2 about as long as lateral width of colored band. (32) Colored band present on tergum 1 or band absent (one specimen).

Female. (42) Tergum 2 with small punctures at sides of basal area, punctures usually not finer towards center. (46) Mesoscutal hairs all white. (47) Hairs short, notaulus and median mesoscutal line visible at least posteriorly. (55) Tergum 1 with apical colored band one-half width of band of tergum 2; band on tergum 2 0.50 mm. wide.

Variation. Much the same type as *m. melanderi.* Scattered individuals of *m. howardi* show some tendency towards one or two of the characters of *m. melanderi,* but are recognizable as *m. howardi* by their totality of characters. The characters studied do not vary in clinal fashion; populations near the range of *m. melanderi* are no nearer to *m. melanderi* than those from distant localities (for an exception to this see discussion under *m. melanderi* on the populations in the Hemet-La Quinta area of southern California).

Type Material. The female holotype of *howardi,* Guaymas, Mexico (L. O. Howard), is at the U. S. National Museum, type number 13455. The male holotype of *californica peninsularis,* Las Animas Bay, Baja California, May 8, 1921 (E. P. Van Duzee), is also there with the type number 55866. The female holotype of *howardi vanduzeei,* Loreto, Baja Califonia Territorio Sur, May 20, 1921 (E. P. Van Duzee), is in the California Academy of Sciences, type number 1509.

Range. This subspecies is found in the desert or desert scrub of the southwestern United States and northwestern Mexico (map 4). This desert is also called the creosote bush desert after the dominant plant, *Larrea tridentata.*

List of Localities. Arizona. Maricopa Co.: Arlington ♂, Agua Caliente (Gila River) ♂, Buckeye (12 mi. E.) 4♂, Goodyear ♂, Theba ♂; Mohave Co.: Topock ♀; Pima Co.: Marana ♂, Sabino Canyon (24 mi. N. E. of Tucson) ♀, Tucson ♂; Pinal Co.: Eloy (10 mi. S. W.) 5♂, (12 mi. S. W.) 3♂, (11 mi. S. W.) ♀5♂, Maricopa ♀♂, Toltec (10 mi. S.) ♀4♂; Santa Cruz Co.: Sonoita ♀; Yuma Co.: Bill Williams River 2♂, Dateland 4♀2♂,

Roll 16 ♀ 23 ♂, Wellton 6 ♀ 3 ♂, Yuma 30 ♀ 14 ♂. CALIFORNIA. Imperial Co. 6 ♀ 3 ♂: Bard 3 ♀, Calexico ♀, El Centro ♀, Experiment Farm (near Meloland) ♀ ♂, Heber (12 mi. E.) ♂, Palo Verde Valley,* Potholes ♀, Westmoreland ♀ 3 ♂; Inyo Co.: Furnace Creek ♂; Riverside Co.: Blythe 47 ♀ 16 ♂, (3 mi. W.) ♀, La Quinta ♀ ♂, Ripley (6 mi. S.) 2 ♀ 2 ♂; San Bernardino Co.: Needles ♂; San Diego Co.: Scissors Crossing (6 mi. N. E. of Banner) 11 ♀ 7 ♂, San Felipe Creek ♂. MÉXICO. Baja California: Bahía las Animas 5 ♂; Baja California Territorio Sur: Coyote Cove (Bahía Concepción) 3 ♀ 4 ♂, Loreto ♀; Sonora: Empalme (16 mi. S. E.) 31 ♀ 10 ♂, Guaymas ♀, (14 mi. N.) ♀.

FLOWER RECORDS. BORAGINACEAE: *Helitropium* sp. 14 ♂, *H. curassavicum* 2 ♂. COMPOSITAE: *Aster spinosus* ♀, *Isocoma veneta* ♂, *Pluchea sericea* ♂. LEGUMINOSAE: *Medicago sativa* 53 ♀ 23 ♂, *Prosopis* sp. ♀, *P. pubescens* 3 ♀. MALVACEAE: *Gossypium* sp. ♀ 4 ♂. SALICACEAE: *Salix exigua* ♀. SOLANACEAE: *Solanum elaeagnifolium* 6 ♀. TAMARICACEAE: *Tamarix* sp. ♀, *T. gallica* 6 ♂, *T. pentandra* 2 ♂. VERBENACEAE: *Lippia lanceolata* 5 ♀.

PARASITES. Mr. R. C. Funk identified mites from the mesothoracic hair of a female from Blythe, California, as *Imparipes americanus* (Acarina: Scutacaridae).

BIOLOGY. Linsley (1946) mentions the nest of *m. howardi*. Nothing else has been published on the biology of this subspecies.

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults.

Nomia (*Acunomia*) *robinsoni* Cresson

(Figs. 11, 26 and 32; Map 4; Table 5)

Nomia robinsoni Cresson, 1865, p. 174 (tax., ♀, ♂); Fox, 1893, p. 134 (tax.); Dalla Torre, 1896, p. 169 (cat.); Cockerell, 1898d, p. 32 (tax.); Cresson, 1916, p. 109 (tax.); Cockerell, 1930, p. 15 (tax.); Krombein, 1953, p. 4 (tax.).

Nomia wickhamii Ashmead, 1896, p. 28 (tax., ♂); Cockerell, 1898d, p. 32 (tax.); Ashmead, 1900, p. 303 (cat.); Cockerell, 1930, p. 15 (tax.), new synonymy.

Nomia robertsonii: Ashmead, 1900, p. 303 (*lapsus calami*) (cat.).

Nomia (*Paranomia*) *robinsoni:* Cockerell, 1910b, p. 297 (tax.).

Nomia (*Paranomia*) *wickhamii:* Cockerell, 1910b, p. 297 (tax.).

Nomia robinsoni wickhamii: Krombein, 1953, p. 4 (tax.).

Nomia (*Acunomia*) *robinsoni:* Cross, 1958a, p. 1264 (tax.).

Nomia (*Acunomia*) *wickhami:* Cross, 1958a, p. 1264 (tax.).

Krombein (1953) states that *wickhamii* is "at most subspecifically distinct from *robinsoni* from Cuba, differing only in lacking ferriginous on the hind femora." Dr. C. D. Michener, who examined the type of *wickhamii* for me, says it differs from the typical *robinsoni* in being darker in leg color and having green bands with yellow iridescence (personal communication). These differences fall within the variation of *robinsoni* from Cuba. It therefore seems best to regard *wickhamii* as synonymous with *robinsoni* until more material from the Bahamas is available or some significant differences are found.

Male. *Structure:* (1) Mandible without lobe on posterior margin. (2) Clypeus with fine, scattered punctures on bare part; bare part raised or with weak longitudinal carina; subapical area flat. (3) Last flagellar segment pointed or rounded, as long as to one and one-third times as long as second flagellar segment. (4) Pronotum with strong carina on posterior, dorsal edge. (5) Scutellum deeply depressed in center, lateral higher parts as punctate or less densely punctate than surrounding area. (6) Metepisternum finely wrinkled. (7) Propodeum with anterior groove slightly or distinctly widened medially. (8) Tegula not marginate on outer edge, subtruncate or rounded posteriorly. (9) Front wing length (see section on methods) 7.3 mm., mean (range: 6.8-7.7). (10) Middle tibial spur curved or straight. (11) Posterior femur three times as long as broad, only basal area nearly impunctate and shining. (12) Posterior tibia produced anteriorly and distally into large lobe with deep apical emargination, which does not hide tips of tibial spurs in side view (fig. 11). (13) Metasomal tergum 1 coarsely punctate except for band of minute punctures at base of apical, depressed, hyaline portion; median width of band varies from three to six rows of punctures, width of band not reduced laterally. (14) Terga 2 to 4 without coarse punctures like those of tergum 1 on raised part of postgradular area; all punctures small and close, apical colored bands not punctate. (15) Sternum 3 with ventrolateral, toothlike process four times as wide as high. (16) Ventroapical median part of gonobase forming rounded projection. (17) Penis valve with small oval ventral opening; valve produced laterally into rounded projection; tip broad and rounded (fig. 32). *Pubescence:* (18) Face, including upper third to half of clypeus covered with short, appressed, plumose, yellowish hairs; lateral part of scape covered with long erect hairs. (19) Longest hairs of face half as long as scape. (20) Anterior margin of genal

area, along eye, with short, appressed, plumose hairs. (21) Hair of anterior part of mesoscutum, of posterior lobe of pronotum, and of anterior part of mesepisternum yellowish. (22) Median mesoscutal line and notaulus obscured by hairs only anteriorly. (23) Metanotum obscured by short, plumose hairs. (24) Tegula covered with fine simple hairs posteriorly. (25) Propodeal hairs yellowish. (26) Longest hairs of tergum 2 as long as lateral width of colored band. (27) Terga 4, sometimes terga 2 and 3, with some black hairs. *Color:* (28) Mandible translucent red-brown, with subapical red area. (29) Flagellar segments orange below. (30) Legs dark brown to orange-yellow except tarsi and underside and apices of tibiae, which are yellow to orange. (31) Stigma brown, about same color as most veins; vein R, intersection of M and Cu, and distal end of V brown to dark brown. (32) Terga 2 to 5 with apical colored bands; band of tergum 5 absent laterally; band color variable, green with orange, gold or yellow iridescence.

FEMALE. *Structure:* (33) Clypeal margin truncate medially; part overhanging base of labrum not hyaline; longitudinal carina weak; clypeus evenly punctate. (34) Face with elevated portion below antennae distinctly punctate. (35) Pronotum with strong carina on posterior, dorsal edge. (36) Mesoscutum and scutellum with scattered punctures; scutellum depressed in center. (37) Mesepisternum with fine wrinkles. (38) Propodeum with anterior groove slightly widened medially. (39) Tegula straight on outer edge, rounded posteriorly. (40) Front wing length (see section on methods) 6.7 mm., mean (range: 6.0-7.4). (41) Metasomal tergum 1 with fine punctures at sides becoming small and more scattered towards center except small oval center area with much closer punctures and band of very minute punctures at base of apical, depressed, hyaline portion; median width of band two-thirds width of hyaline portion. (42) Tergum 2 with minute punctures at side of basal area, punctures becoming much finer toward center. (43) Tergum 3 with gradular ridge indistinct and punctate. *Pubescence:* (44) Longest hairs of face shorter than distance from antenna to inner eye margin. (45) Anterior margin of genal area, along eye, with short, appressed, plumose hairs. (46) Mesoscutal hairs yellowish or white anteriorly and darker posteriorly. (47) Notaulus and median mesoscutal line visible at least posteriorly. (48) Metanotum completely obscured by short, plumose hairs; longer black hairs absent. (49) Tegula covered with plumose hairs posteriorly. (50) Tergum 1 with lateral part of hyaline por-

tion obscured by appressed dense mat of hairs. (51) Terga 2 to 4 with some black hairs. *Color:* (52) Antennae light brown below. (53) Stigma brown, about same color as most veins; vein R and distal end of V dark brown. (54) Legs brown, sometimes hind tibia and tarsus orange. (55) Terga 2 to 5 with apical colored bands; band color green with gold or yellow iridescence.

VARIATION. There are too few specimens of *robinsoni* from too few localities to draw many conclusions concerning its variation. There is a high intrapopulational variation in integument and band color in the males. The male ultimate antennal segment is highly variable in shape and length. The specimens from the Bahamas (*wickhamii*) and Mexico fall within the range of variation of the Cuban material.

TYPE MATERIAL. *N. robinsoni* was described from one female and three males from Cuba. In 1916 Cresson designated a male lectotype, in the Academy of Natural Sciences of Philadelphia, type number 2136. *N. wickhamii* was described from two males from Eleuthera Island, Bahamas. One of these, which is labeled holotype, is in the U. S. National Museum with the type number 12990 (Ditzen collector?). The other specimen must be lost, for I have not been able to find it, and Krombein (1953) says that *wickhamii* "is known only from the unique male type."

RANGE. Cuba, eastern Mexico(?) and the Bahamas (map 4).

LIST OF LOCALITIES. BAHAMAS. Eleuthera Island ♂. CUBA. Camagüey: Baraguá ♂, Camagüey ♂; Habana: Habana 6 ♀ 4 ♂, Santiago de las Vegas 3 ♂; Las Villas: Zaza del Medio ♂; Oriente: Cayamas ♀, Santiago de Cuba ♀ ♂; Pinar del Rio: Cabañas ♂, Pinar del Rio ♀, San Vicente 2 ♂, Vinales ♀, (7 km. N.) ♀ 18 ♂, (14 km. N.) ♂, (24 km. N.) 5 ♀; Province?: Soledad ♂. MÉXICO. Veracruz: Nogales ♂.

PARASITES. Mr. R. C. Funk identified mites from the sixth abdominal sternum of a male from Vinales (7 km. N.) as *Glyphanoetus* sp. (Acarina: Anoetidae).

SEASONAL ACTIVITY. Table 5 gives the seasonal activity of the adults from Cuba.

The male (only specimen) from Nogales, Veracruz, Mexico, was collected in April, 1956 (N. L. H. Krauss), and was pinned and labeled at the University of Kansas. As the same collector was in Cuba at about the same time, an error in labeling is a possibility.

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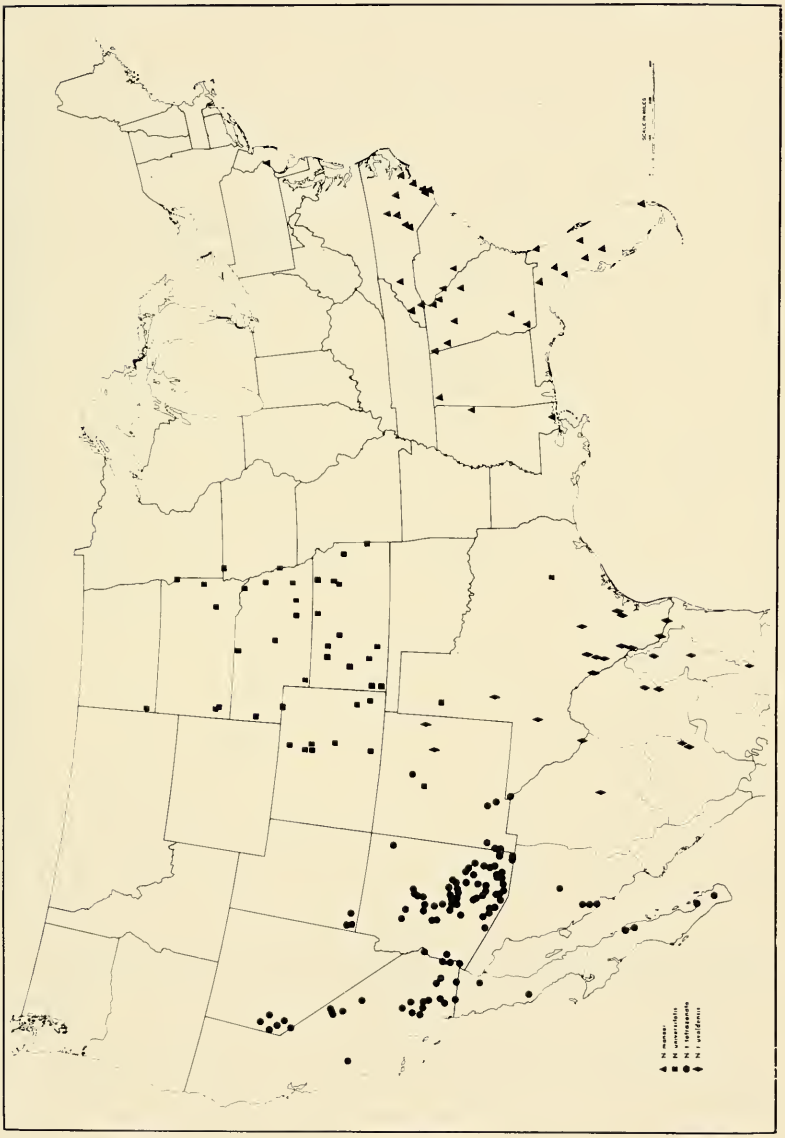
MAP 1

The distribution of *Nomia (Curvinomia) maneei, N. (C.) universitatis, N. (C.) t. tetrazonata* and *N. (C.) t. uvaldensis.*



MAP 2

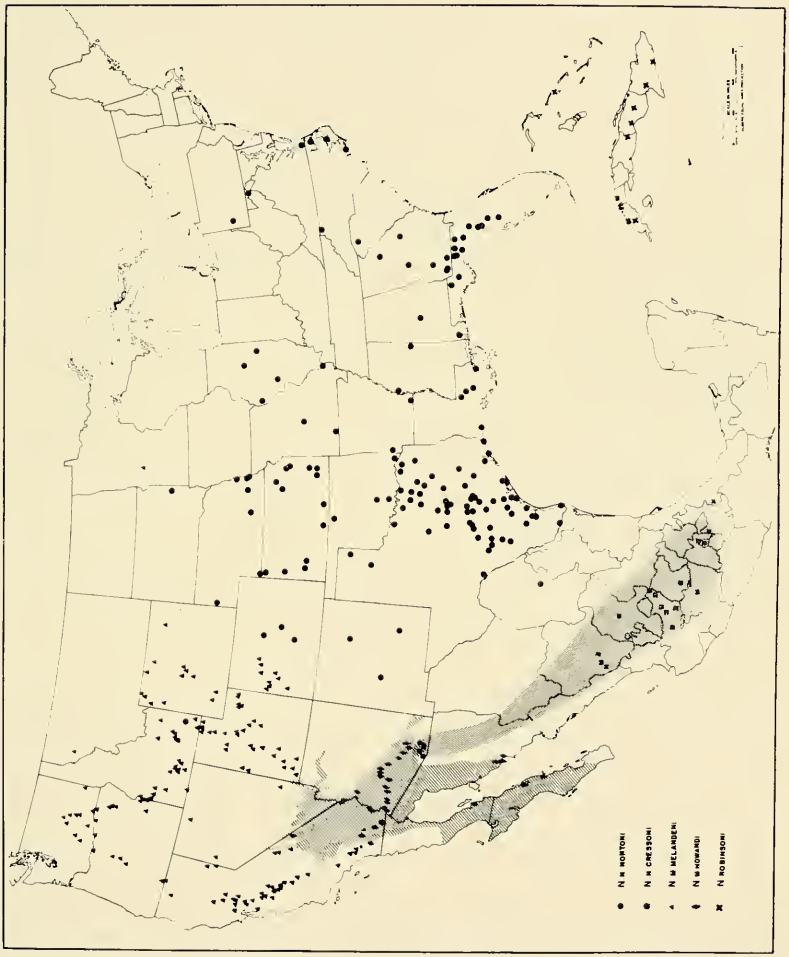
The distribution of *Nomia (Curvinomia) foxii* and *N. (C.) fedorensis.*

MAP 3

The distribution of *Nomia (Curvinomia) angustitibialis.*

MAP 4

The distribution of the species and subspecies of *Nomia (Acunomia).* The probable range of *N. (A.) melanderi howardi* is shaded to correspond with the western range of *Larrea* in the United States and with the western desert of Mexico. Hemet and La Quinta are indicated by a and b respectively in the range of *N. (A.) melanderi.* The shading of *N. (A.) nortoni cressoni* is used only to emphasize its range.


N. n. NORTONI
N. n. CRESSONI
N. n. MELANDERI
N. n. HOWARDI
N. ROBINSONI

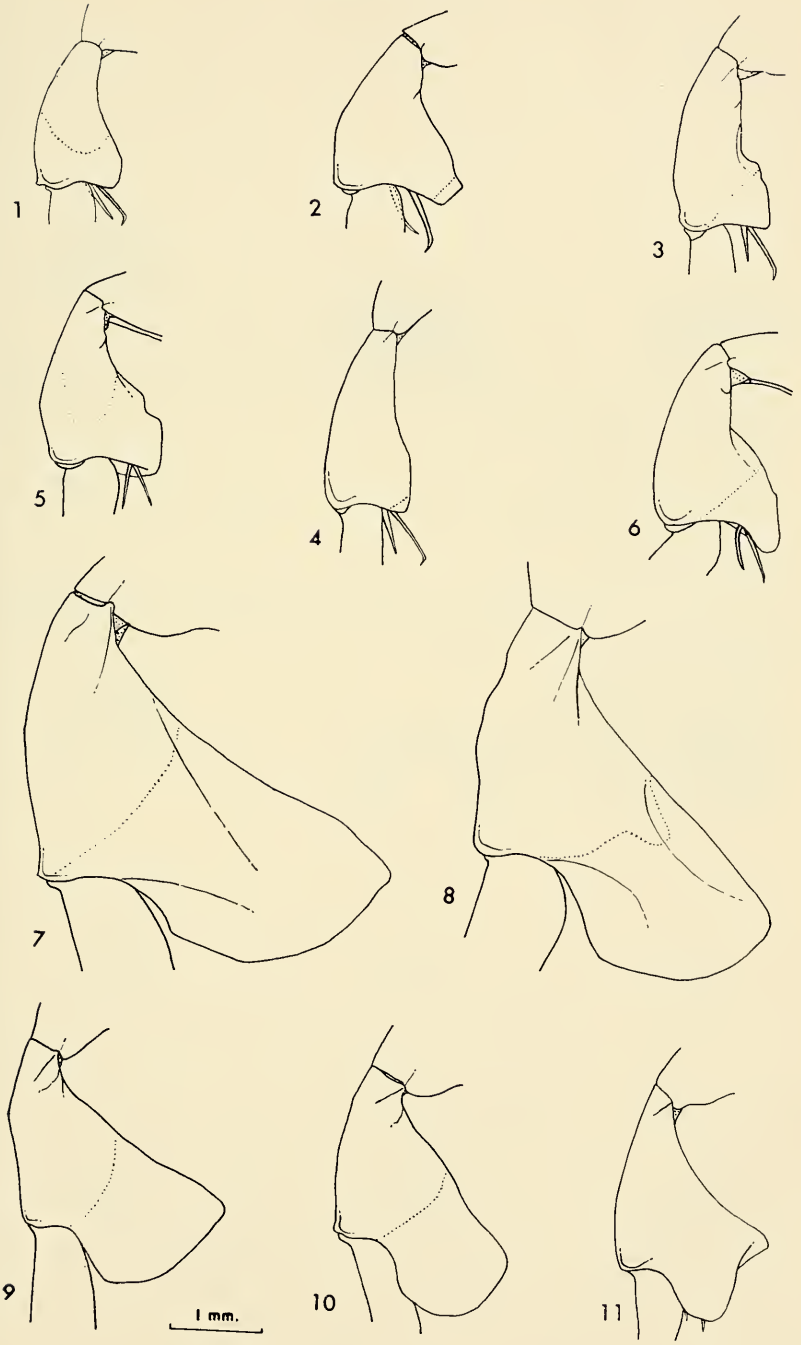
FIGURES 1-11

FIGS. 1-11. *Nomia (Curvinomia)* and *N. (Acunomia)* species. Right hind tibia, male, side view.

1. *N. (C.) maneei.*
2. *N. (C.) fedorensis.*
3. *N. (C.) universitatis.*
4. *N. (C.) angustitibialis.*
5. *N. (C.) foxii.*
6. *N. (C.) tetrazonata waldensis*
7. *N. (A.) n. nortoni.*
8. *N. (A.) n. cressoni.*
9. *N. (A.) m. melanderi.*
10. *N. (A.) m. howardi.*
11. *N. (A.) robinsoni.*

The area below the dotted line is lighter in color and translucent.

FIGURES 1-11



FIGURES 12-23

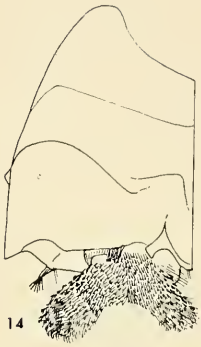
FIGS. 12-17. *Nomia (Curvinoma)* species. Metasomal sternum 5, male, ventral aspect, right side only.

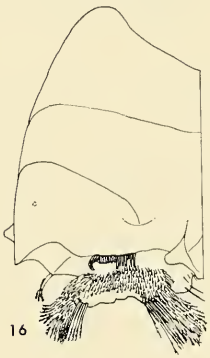
12. *N. (C.) maneei.*
13. *N. (C.) fedorensis.*
14. *N. (C.) universitatis.*
15. *N. (C.) angustitibialis,* with enlargements of hairs.
16. *N. (C.) foxii.*
17. *N. (C.) t. tetrazonata.*

FIGS. 18-23. *Nomia (Curvinomia)* species. Left penis valve, ventral view; above, tip of penis valve, side view.

18. *N. (C.) maneei.*
19. *N. (C.) fedorensis.*
20. *N. (C.) universitatis.*
21. *N. (C.) angustitibialis.*
22. *N. (C.) foxii.*
23. *N. (C.) t. tetrazonata.*

FIGURES 12-23





FIGURES 24-32

FIGS. 24-26. *Nomia (Acunomia)* species. Metasomal sternum 5, male, ventral aspect.

24. *N. (A.) n. nortoni,* the letters refer to structures discussed in the text: a. median, basal emargination, b. fused row of setae, c. lateroapical hairy pad, d. median, apical process, e. median, longitudinal ridge.

25. *N. (A.) m. melanderi,* with enlargements of hairs.

26. *N. (A.) robinsoni.*

FIGS. 27-29. *Nomia (Acunomia) m. melanderi.* Metasomal sternum 6-8, male, ventral aspect, right side only. Fig. 27. Sternum 6. Fig. 28. Sternum 7. Fig. 29. Sternum 8.

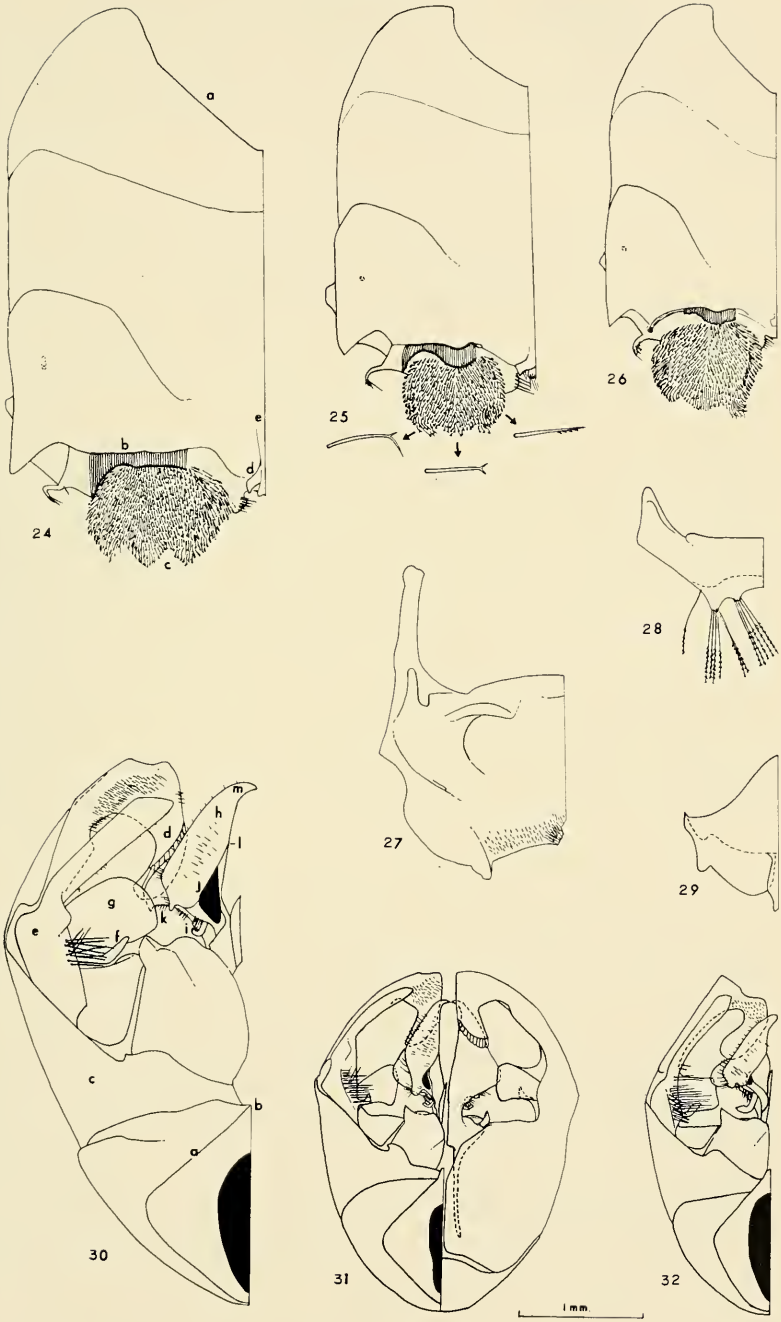
FIGS. 30-32. *Nomia (Acunomia)* species. Genitalia, left side only.

30. *N. (A.) n. nortoni,* ventral view, the letters refer to structures discussed in the text: a. gonobase, b. ventroapical, median part of gonobase, c. gonocoxite, d. dorsal recurved part of gonocoxite, e. gonostylus, f. hooklike process of gonostylus, g. basal plate of gonostylus, h. penis valve, i. anteroventral process of penis valve, j. ventral opening of penis valve, k. lateral part of penis valve, l. inner subapical margin of penis valve, m. tip of penis valve.

31. *N. (A.) m. melanderi,* ventral (left) and dorsal view (right).

32. *N. (A.) robinsoni,* ventral view.

FIGURES 24-32



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A Taxonomic Study of the Subgenus *Ladona* (Odonata: Libellulidae)*

BY

BILLY L. BENNEFIELD

INTRODUCTION

This paper is the result of a taxonomic study of the dragonfly subgenus *Ladona* in the Nearctic region. Some material concerning the biology of the group is also included, as well as a study of variation within one species, *Libellula* (*Ladona*) *julia*. Some 1,200 adults and 15 nymphs of the subgenus were examined.

Prior to this work, the taxonomy of this group has been based largely on coloration, and descriptions were based on relatively few specimens from one or two localities. For this reason, emphasis has here been placed on the recognition of taxonomic characters other than coloration, and an attempt has been made to re-describe the species more exactly on the basis of these characters as well as coloration.

TECHNIQUES AND TERMINOLOGY

The characters and terminology used in the keys are, for the most part, self-explanatory or are clarified by illustrations. However, to facilitate accurate and rapid interpretation of descriptions, certain techniques and terms are explained.

All measurements listed are in millimeters. Gross body measurements (*e. g.*, wing length) were made with a standard millimeter rule. Measurements requiring finer divisions (*e. g.*, stigma) were made with an ocular micrometer. The following measurements were made:

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1. Total length—maximum mid-dorsal, from front of head to distal ends of anal appendages, to nearest millimeter.
2. Abdomen—maximum mid-dorsal length from anterior transverse carina of segment I to distal ends of anal appendages.
3. Fore wing—maximum length from tip to base.
4. Hind wing—maximum length from tip to base.
5. Stigma—along costa of fore wing.
6. Length nodus to stigma—maximum along costa from nodus to proximal edge of stigma of fore wing.
7. Metathoracic femur—maximum length along lateral meson.
8. Front, middle, and hind tibiae—maximum length along lateral meson.
9. Head width—maximum, dorsal view at eye level.
10. Superior anal appendage—maximum mid-lateral length.
11. Supra-anal plate—maximum length in lateral view.

The size of all structures drawn is indicated in millimeters and is given as actual size.

Color, which was used almost entirely in the descriptions of earlier workers, has been found to be variable and in some cases of reduced value in species recognition. There is color variation both with age and geographical distribution. Few, if any, individuals will be found to agree in every detail with the original color descriptions. An attempt has been made to treat coloration in the species descriptions in such a way as to include as much of the range of variation as possible.

In order to facilitate a more accurate description of coloration of the lateral surface of the synthorax, the individual sclerites are considered. All color determinations were made using low (15 ×) magnification with an unfiltered light source directed from above.

The coloration of the wings is relatively stable and reliable within species. In order to discuss this coloration, the term interspace has been used (*e. g.*, costal-subcostal interspace). This refers to the space between the two veins named.

While the female genitalia were found to be similar in all three species and thus of little use in species determination, those of the male, especially the penis and posterior hamules, were found to be specifically distinct. Observation of the penis usually necessitates its removal from the specimen. For observations of the other characters used in this paper, clearing is not necessary. The morphological terminology used for the description of the penis is that of Chao (1953) and differs somewhat from the terms used by Kennedy (1922). Other morphological terminology has also been adopted from Chao (1953).

DESCRIPTION AND TAXONOMIC HISTORY OF THE SUBGENUS LADONA NEEDHAM 1897

Libellula, Williamson, 1900, Rpt. Indiana Dept. Geol., vol. 24, p. 328; Calvert, 1906, Biologia Centrali-Americana, Neuroptera, p. 206; Williamson, 1922, Ent. News, vol. 33, p. 18; Byers, 1927, Ent. News, vol. 38, pp. 113-114; Calvert, 1927, Univ. Indiana Stud. Nat. Hist., vol. 12, p. 2; Byers, 1930, Univ. Florida Pub. Biol. Sci., vol. 1, pp. 106, 111; Byers, 1936, Ent. News, vol. 47, p. 62.

Ladona, Needham, 1897, Canadian Ent., vol. 29, pp. 144-149; Needham, 1901, Bull. New York St. Mus., vol. 47, pp. 507-508, 528; Muttkowski, 1908, Bull. Wisconsin Nat. Hist. Soc., vol. 6, pp. 105, 115; Needham and Heywood, 1929, Handbook of North American Dragonflies, pp. 202, 204, 217; Needham and Fisher, 1936, Tran. American Ent. Soc., vol. 62, pp. 113, 115; Brimley, 1938, Insects of North Carolina, p. 39; Wright and Peterson, 1944, Ohio Jour. Sci., vol. 44, pp. 158, 165; Needham and Westfall, 1955, Dragonflies of North America, pp. 58, 426, 428, 431-432, 473; Smith and Pritchard, 1956, Aquatic Insects of California, p. 124.

Libellula (*Ladona*), Borror, 1945, Ann. Ent. Soc. America, vol. 38, pp. 171, 174, 175, 192; Ris, 1910, Coll. de Selys, vol. 10, p. 245; Kennedy, 1922, Ent. News, vol. 33, pp. 105, 109, 110.

Type Species: *Libellula exusta* Say, 1839.

This subgenus is composed of dragonflies of medium size, which may be readily separated from the other members of the genus *Libellula* by vein M_{1a} which arises before the middle of the stigma. The wings are clear with basal brown spots. There is usually one crossvein present in the super triangle, and usually in the anal area behind vein A_2 there are three well defined rows of cells.

The abdomen gradually tapers posteriorly and is relatively uniform in coloration in *exusta* and *deplanata*, while *julia* usually bears white coloration on the first four segments.

The posterior lobe of the middle segment of the penis is considerably more reduced, and the cornula of the penis is relatively shorter and more inconspicuous than in other members of the genus *Libellula*.

The members of this group are associated with ponds. They are rapid flyers and fly quite close to the surface of the water. They exhibit a preference for bare, sunny areas when at rest. The female lays her eggs while hovering over the surface of the water.

The known nymphs may be readily separated from the other nymphs of *Libellula* on the basis of the crenulate median lobe of the labium. All other nymphs of the genus *Libellula* have the median lobe of the labium smooth and evenly contoured.

The members of this subgenus range from the southeastern Canadian provinces through some of the central and southern states to Florida, westward to Washington (Fig. 1).

Three species form this subgenus. The status of these three species was confused by many early authors. Hagen (1861) considered *deplanata* as a synonym of *exusta* and later (1875) considered *deplanata* as a southern form of *exusta* and *julia* as a synonym of *exusta*. Calvert (1893) placed both *julia* and *deplanata* as synonyms of *exusta*. The three species were then considered under the name *exusta* until 1897. At this time, Needham (1897) recognized all three species and erected the genus *Ladona* to contain them, with *exusta* as the type species. Due to the uniqueness of the type species of *Libellula*, Needham felt that all American species of the genus *Libellula* should be placed in other genera, hence the proposal of the genus *Ladona*. It is now generally agreed that this step was not necessary.

The genus *Ladona* was not well received, and many workers such as Ris (1910), Garman (1927), Byers (1930), and others continued to place its species in *Libellula*. In addition, the taxonomic rank of the three forms continued in dispute. For example, Muttkowski (1910) considered *julia* as a synonym of *exusta* and *deplanata* as a subspecies of *julia*. Byers (1930) considered *julia* as a synonym of *exusta* and recognized only two species, *exusta* and *deplanata*.

Several authors have considered the three species to form a subgenus of *Libellula*. For example, Kennedy (1922) developed a phylogeny for the genus *Libellula* on the basis of the morphology of the penis and placed *Ladona* as a subgenus. The results of Kennedy's study agree largely with those of Ris (1910). In view of these varied opinions, it seemed worthwhile to re-examine the evidence in order to form a sound judgment as to the status of *Ladona*. In order to accomplish this, two species of *Libellula* (*semifasciata* and *pulchella*) and one of *Ladona* (*julia*) were chosen. It was felt that a comparison of these three species would indicate the degree of relationship between the two groups. *Libellula semifasciata* Burmeister was chosen since it is considered to represent the most primitive species of *Libellula* (Kennedy, 1922). *Libellula pulchella* Drury was chosen as a typical representative of the genus *Libellula*. *Ladona julia* was chosen since it appears to be the most primitive of the three species of *Ladona* (Kennedy, 1922). Among the many morphological features studied, only the following differences were noted:

1. The epistomal suture is quite convex in *semifasciata*, slightly convex in *pulchella*, and virtually straight in *julia*.

2. In *semifasciata* the anterior margin of the median lobe of the labium is broadly pointed; in *pulchella* this structure is much less pointed, and in *julia* it is evenly contoured.

3. *Libellula semifasciata* exhibits a distinct notch or break in the middle lobe of the prothorax; this is less apparent in *pulchella* and absent in *julia.*

4. The posterior margin of the posterior lobe of the prothorax in *julia* was observed to have a fan-shaped expanse of hairs not found in either *semifasciata* or *pulchella.*

5. The dorsal lobe of the eucervicale is somewhat more rounded in *semifasciata* than in *pulchella* or *julia.*

6. The mesopleural suture is less sigmoid in *julia* than in either *semifasciata* or *pulchella.*

7. The metapleural suture is straight in *semifasciata,* sigmoid in *pulchella* and *julia.*

On the basis of these comparisons, the placement of *Ladona* at the subgeneric level seems most appropriate. After a study of wing venation, Borror (1945) reached the same conclusion and also treated *Ladona* as a subgenus.

Key to Males of the Subgenus *Ladona*

1. Dorsum of anepisternum II without lateral antehumeral stripe; abdominal segments IV-IX laterally black with irregular brown ventral spots, or wholly black; subcostal-radial and medial interspace of hindwing dark brown to level of second or third antenodal crossvein; radial and medial-postcubital interspace of both wings marked faintly with brown (Fig. 8); posterior ventral margin of segment X concave ..... *julia*

   Dorsum of anepisternum II with two lateral antehumeral stripes; abdominal segments IV-IX wholly black or with dorsal black triangles; subcostal-radial and medial interspace of hindwing dark to a level beyond third antenodal crossvein; radial and medial-postcubital interspace clear or faintly marked with brown; posterior ventral margin of segment X straight or concave 2

2. Dorsum of anepisternum II brown with two yellow antehumeral stripes; abdominal segments IV-IX with dorsal black triangles; subcostal-radial and medial interspace of hindwing dark brown to level of fourth or fifth antenodal crossvein; radial and medial-postcubital interspaces of both wings clear (Fig. 9); posterior ventral margin of segment X straight ..... *deplanata*

   Dorsum of anepisternum II medium brown with two yellow-gray antehumeral stripes; abdominal segments wholly black in mature specimens; subcostal-radial and medial interspace of hindwing dark brown to level of fifth or sixth antenodal crossvein (Fig. 10); radial and medial-postcubital interspaces of both wings marked faintly with brown; posterior ventral margin of segment X concave ..... *exusta*

Key to Females of Subgenus *Ladona*

1. Dorsum of anepisternum II uniform cream to brown; antehumeral stripes absent ..... *julia*

   Dorsum of anepisternum II light brown to brown; antehumeral stripes present 2

2. Dorsum of anepisternum II brown with two cream antehumeral stripes, darkening with age; radial and medial-postcubital interspace of both wings clear (Fig. 9) ..... *deplanata*

   Dorsum of anepisternum II light brown with two gray antehumeral stripes; radial and medial-postcubital interspace of both wings marked with brown (Fig. 10) ..... *exusta*

Key to Known Nymphs of Subgenus *Ladona*

1. Mental setae three ..... *julia*
   Mental setae absent ..... *deplanata*

Libellula (*Ladona*) *julia* Uhler

Libellula julia Uhler, 1857, Proc. Acad. Nat. Sci. Philadelphia, p. 88; Hagen, 1861, Synopsis of Neuroptera of North America, p. 153; Kirby, 1890, Synoptic Catalogue of Neuroptera-Odonata, p. 26; Calvert, 1893, Trans. American Ent. Soc., vol. 20, p. 258; Calvert, 1905, Occ. Pap. Boston Soc. Nat. Hist., vol. 7, p. 34; Walker, 1906, Canadian Ent., vol. 38, p. 153; Walker, 1906, Rpt. Ent. Soc. Ontario, vol. 36, p. 70; Williamson, 1907, Ohio Nat., vol. 7, p. 150; Muttkowski, 1908, Bull. Wisconsin Nat. Hist. Soc., vol. 6, p. 166; Walker, 1915, Rpt. Ontario Dept. Marine Fish., vol. 47 (supplement), pp. 51, 59, 91; Howe, 1920, Mem. Thoreau Mus., vol. 2, pp. 71, 97, 101; Howe, 1921, Mem. Thoreau Mus., vol. 2 (supplement), p. 1; Howe, 1921, Proc. Boston Soc. Nat. Hist., vol. 36, p. 128; Walker, 1928, Univ. Toronto Stud. Biol. Sci., vol. 32, p. 43; Walker, 1929, Ent. News, vol. 40, p. 243; Walker, 1932, Univ. Toronto Stud., Pub. Ontario Fish Res. Lab., vol. 48, pp. 229, 244; Walker, 1933, Canadian Ent., vol. 65, p. 69; Walker, 1934, Rpt. Quebec Soc. Prot., vol. 26, p. 11; Walker, 1940, Canadian Ent., vol. 72, pp. 32-33; Walker, 1941, Trans. Roy. Canadian Inst., vol. 23, pp. 205, 206, 216, 253; Walker, 1942, Proc. Nova Scotia Inst. Sci., vol. 20, p. 173.

Ladona julia; Needham, 1901, Bull. New York St. Mus., vol. 47, pp. 520, 529, 530, 531; MacGillivray and Houghton, 1903, Ent. News, vol. 14, p. 263; Needham, 1903, Bull. New York St. Mus., vol. 68, pp. 246, 247; Needham and Anthony, 1903, Jour. New York Ent. Soc., vol. 11, p. 122; Osburn, 1905, Ent. News, vol. 16, p. 195; Byers, 1927, Ent. News, vol. 38, p. 114; Needham and Heywood, 1929, Handbook of Dragonflies of North America, pp. 217, 218; Byers, 1930, Univ. Florida Pub. Biol. Sci., vol. 1, pp. 111, 112; Borror, 1935, Ohio Jour. Sci., vol. 35, p. 454; Borror, 1937, Ohio Jour. Sci., vol. 37, p. 190; Borror, 1940, Ent. News, vol. 51, p. 78; Ahrens, 1941, Ent. News, vol. 52, p. 287; Montgomery, 1941, Proc. Indiana Acad. Sci., vol. 50, p. 250; Montgomery, 1943, Ent. News, vol. 54, p. 3; Gillespie, 1945, Ent. News, vol. 56, p. 62; Montgomery, 1945, Proc. Indiana Acad. Sci., vol. 54, pp. 218, 221, 223; Bromley, 1948, Proc. Ent. Soc. Washington, vol. 50, p. 237; Whitehouse, 1948, Trans. Roy. Canadian Inst., vol. 27, p. 37; Price, 1950, Ohio Jour. Sci., vol. 50, p. 37; Needham and Westfall, 1955, Dragonflies of North America, pp. 58, 473-475, 477.

Libellula (Ladona) julia; Borror, 1945, Ann. Ent. Soc. America, vol. 38, pp. 171, 174, 175, 192; Ris, 1910, Coll. de Selys, vol. 11, p. 248; Kennedy, 1922, Ent. News, vol. 33, pp. 68-70, 111.

TYPES. Male holotype, located in the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts. Type with most of right forewing missing, the tips of both hind wings and both hind tarsi missing.

MALE. Measurements: Total length, 39.29 ± 1.558 mm. (holotype 40.50 mm.); abdomen length, 24.50 ± 1.024 mm. (holotype 26.00 mm.); forewing length, 31.93 ± 1.888 mm. (holotype 30.50 mm.); hind wing length, 30.82 ± 1.142 mm. (holotype about 30.40 mm.); stigma length, 3.18 ± .1557 mm.; length nodus to stigma, 11.66 ± .655 mm. (holotype 11.60 mm.); metathoracic femur length, 6.23 ± .282 mm. (holotype 6.6 mm.); prothoracic tibia length, 4.43

± .244 mm. (holotype 4.80 mm.); mesothoracic tibia length, 4.78 ± .265 mm. (holotype 5.30 mm.); metathoracic tibia length, 6.21 ± .318 mm. (holotype 6.60 mm.); head width, 6.93 ± .196 mm. (holotype 6.70 mm.); superior anal appendage length, 1.97 ± .114 mm. (holotype 2.0 mm.); supra-anal plate length, 1.36 ± .104 mm. (holotype 1.50 mm.).

Head with parietal region tan; compound eyes dark reddish brown; vertex black with punctate appearance; frons peripherally black, becoming tan ventrally with central portion cream, becoming uniformly black with age; epistomal suture appearing as gray or black straight groove; postclypeus light tan with anterior tentorial pits visible as light yellow patches, becoming dark with age; anteclypeus tan to light brown, becoming darker with age; labrum orange with occasional darker median area; labium light yellow to orange with median lobe partially or wholly black, lateral lobes orange often with varying amounts of black.

Prothorax with dorsal margin of anterior lobe gold, remainder black; middle lobe black with median ridge brown, bearing white hairs; posterior lobe black, bearing long white hairs laterally and posteriorly in fan-like fashion; dorsal lobe of eucervicale with anterior half gold, remainder black.

Synthorax with acrotergite II black; mesostigmal plates black; area posterior to pit of tergal apophysis II black becoming light brown; collar carina light brown; dorsal carina black bordered by brown stripes; antealar carina black; antealar sinus white; anepisternum II dorsally white, laterally a uniform dark brown; katepisternum II with dorsal one-third dark brown as anepisternum II, remainder light brown; mesopleural suture deepened dorsally and ventrally to form deep grooves surrounded by blue-black spots; epimeron II light brown with occasional traces of darker brown dorsally; anepisternum III light brown; katepisternum III light brown; epimeron III light brown; metapleural suture deepened dorsally and ventrally to form deep grooves surrounded by black spots.

Forewing with subcostal-radial and medial interspace dark brown to level of first antenodal crossvein, occasionally to second antenodal crossvein; radial and medial-postcubital interspace marked very faintly with light brown; postcubital-anal interspace dark brown, color extending approximately half way to anal crossing; stigma light tan, subtending two to three cells; antenodal crossveins 12 to 16; postnodal crossveins 9 to 13. Hind wing with

subcostal-radial and medial interspace dark brown, the color extending to level of second antenodal crossvein, occasionally to level of third antenodal crossvein; radial and medial-postcubital interspace marked with light brown; postcubital-anal interspace very dark brown, the color extending approximately half way to anal crossing; first anal interspace with dark brown triangle; stigma light tan, subtending two to three cells; antenodal crossveins 10 to 13; postnodal crossveins 9 to 14 (Fig. 8).

Legs with femora black, occasionally becoming brown dorsally; tibiae black with yellow stripes on outer surface; tarsi black.

Abdomen with segment I uniform light brown; segments II-IV white dorsally and laterally, rarely becoming darkened; segments V-VIII black dorsally and laterally, usually with irregular light brown spots on ventral region of lateral surface; segment IX black dorsally and laterally, gonopophyses light brown; segment X black dorsally and laterally, posterior ventral margin convex; supplementary transverse carinae black; posterior transverse carinae black with black spines; submarginal ventral carinae black; ventral carinae light brown; acrotergites white to light brown; ventral surfaces of segments tan to light brown.

Superior anal appendages brown darkening with age, pointed; inferior anal laminae widely separated.

Penis with stem somewhat constricted, posterior projection sharply rounded; posterior margin of middle segment smooth; distal segment a broad pedicel; cornula sharply pointed posteriorly, broadly rounded anteriorly (Fig. 2).

Posterior hamuli bifurcate with anterior process bearing a single laterally directed hook; lateral lobe sharply rounded (Fig. 3).

FEMALE. Measurements: Total length, 37.45 ± 1.616 mm.; abdomen length, 23.86 ± 1.316 mm.; forewing length, 32.0 ± 1.663 mm.; hind wing length, 30.85 ± 1.625 mm.; stigma length, 3.61 ± .883 mm.; length nodus to stigma, 11.52 ± .589 mm.; metathoracic femur length, 5.73 ± .527 mm.; prothoracic tibia length, 4.15 ± .866 mm.; mesothoracic tibia length, 4.56 ± .986 mm.; metathoracic tibia length, 6.28 ± .215 mm.; head width, 6.84 ± .725 mm.; superior anal appendage length, 1.04 ± .454 mm.

Head with parietal region light tan; compound eyes as in male; vertex with dorsal half dark tan, ventral half black, becoming wholly dark with age; ocelli surrounded by light yellow border; frons uniform tan with occasional yellow spots, darkening with age; epistomal suture appearing as a straight colorless groove;

postclypeus tan with ventral margin occasionally yellow, becoming greenish brown with age; anteclypeus as postclypeus, occasionally marked with irregular yellow lines; labrum yellow with darker median area; labium as in male.

Prothorax with anterior lobe as in male; middle lobe as in male but with median ridge more pronounced; posterior lobe as in male but with longer hairs; dorsal lobe of eucervicale with more extensive gold coloration than in male.

Synthorax with acrotergite, mesostigmal plates, area posterior to pit of tergal apophysis II, and collar carina as in male; dorsal carina black, with faint stripe dorsally; antealar carina tan; antealar sinus brown to tan; anepisternum II dorsally cream with occasional irregular brown areas, becoming brown with age; anepisternum II laterally dark brown as in male; remainder of synthorax as in male.

Forewing with costal-subcostal interspace very light brown, the color extending to level of first antenodal crossvein; subcostal-radial and medial interspace dark brown to level of first or second antenodal crossvein; radial and medial-postcubital interspace very light brown as in costal-subcostal interspace, more extensive and slightly darker than in male; postcubital-anal interspace very dark brown extending to anal crossing; stigma brownish, darker than in male, subtending two to three cells; antenodal crossveins 13 to 16; postnodal crossveins 10 to 13. Hindwing with costal-subcostal interspace very faint brown to level of first antenodal crossvein; subcostal-radial and medial interspace dark brown to level of third antenodal crossvein; radial and medial-postcubital interspace as in forewing, more extensive than in male, extending to arculus; postcubital-anal interspace dark brown to a point approximately half way beyond anal crossing; first anal interspace with brown triangle somewhat larger than in male; stigma as in forewing; antenodal crossveins 10 to 13; postnodal crossveins 9 to 13.

Legs as in male.

Abdomen with segment I dorsally black, becoming tan laterally and ventrally; segments II-III tan to brown dorsally, light tan laterally and ventrally; segments IV-IX with median dorsal black stripe, laterally tan to light brown with dorsal and ventral black margins, tan or light brown areas in these segments being gradually reduced in each segment, with segment IX almost wholly black; spines of posterior transverse carinae progressively more pronounced posteriorly; segment X with dorsal half black, ventral half light brown; supplementary transverse carina black; posterior transverse

carinae black; submarginal ventral carinae black; ventral carinae black; acrotergite light brown; antecostal sutures yellow or black.

Anal appendage brown to black, elongate with broadly rounded apex, shorter than segment X; supra-anal plate tan to brown with broadly rounded apex, shorter than anal appendage.

NYMPH. Total length, 20-22 mm.; mentum with prominent median projection; mental setae three; dorsal abdominal hooks overlapping less than half of following segment; length of anal appendage 2.5 mm.; length of abdominal segments IX-X 2.0 mm.

BIONOMICS. Needham (1897) reported this species to frequent small ponds and the borders of adjacent woods. Kormondy (1958) reported *julia* to be virtually ubiquitous in Michigan with a wide range of aquatic habitats. Needham stated that this species has leisurely flight with hovering and darting movements, whereas both Gillespie (1945) and Borror (1940) have indicated it to be a fast flier and difficult to catch. Gillespie reported having observed the species flying swiftly over water, close to the surface in an "un-*Libellula*" fashion. The males are found in low places around ponds, resting on the ground with wings aslant and forward. The females oviposit while hovering over the water, otherwise remaining largely in the woods surrounding the ponds. Osburn (1905) reported this species in the late afternoon resting on stones in large numbers, some distance from a lake, with their wings outspread against the sides of the rocks, and when disturbed they would fly to other rocks and assume the same position. Osburn pointed out that due to their coloration, these dragonflies were inconspicuous except where the rocks had been blackened by recent forest fires. Stumps and tree roots seemed to have no attraction as resting sites. Needham (1897, 1901) indicated that the nymphs of *julia* are active, resting with the abdominal appendages widely spread apart, and transform in association with *Tetragoneuria*.

DISTRIBUTION. Type locality: "Puget Sound," Washington. CONNECTICUT: Litchfield Co. (7 ♂, 1 ♀) (20 June-5 July); Tolland Co. (17 ♂, 2 ♀) (14 June). INDIANA: Wells Co. (1 ♂) (28 May); Elkhart Co. (3 ♂, 3 ♀) (20 May). MAINE: Androscoggin Co. (1 ♀) (3 July); Kennebec Co. (2 ♂, 1 ♀) (26 June); Lincoln Co. (17 ♂, 4 ♀) (11 June-30 July); Penobscot Co. (1 ♀) (29 June). MASSACHUSETTS: Barnstable Co. (1 ♂) (24 May); Hampden Co. (1 ♂, 2 ♀) (20-22 June); Middlesex Co. (10 ♂, 4 ♀) (29 May-14 July); Norfolk Co. (5 ♂, 1 ♀) (8 June-10 July); Worcester Co. (4 ♂, 2 ♀) (2 July). MICHIGAN: Alger Co. (1 ♂, 1 ♀) (July);

Baraga Co. (1 ♂) (5 July); Charlevoix Co. (5 ♂, 2 ♀) (15 June-5 July); Cheboygan Co. (22 ♂, 7 ♀) (29 May-29 July); Chippewa Co. (2 ♂) (20-21 July); Clare Co. (1 ♂) (3 July); Clinton Co. (1 ♀) (no date); Dickinson Co. (1 ♂, 1 ♀) (17 July); Emmet Co. (2 ♂, 2 ♀) (21 May-7 July); Genesee Co. (1 ♂, 1 ♀) (25 June); Gladwin Co. (4 ♂) (16-22 June); Gogebic Co. (1 ♂, 1 ♀) (3 July); Grand Traverse Co. (10 ♂, 5 ♀) (27 June); Houghton Co. (3 ♂) (14 June-8 July); Ingham Co. (3 ♀) (10 May); Iosco Co. (2 ♂, 4 ♀) (21 July); Iron Co. (3 ♂, 2 ♀) (17 June); Kent Co. (1 ♂, 1 ♀) (30 May); Keweenaw Co. (7 ♂, 5 ♀) (11 June-5 July); Livingston Co. (6 ♂, 13 ♀) (2-10 June); Luce Co. (6 ♂, 7 ♀) (26 June); Mackinac Co. (12 ♂, 9 ♀) (14 June-28 July); Marquette Co. (5 ♂, 1 ♀) (23 June-18 July); Mason Co. (1 ♂) (25 July); Menominee Co. (5 ♂, 1 ♀) (18 June-12 July); Midland Co. (1 ♂) (25 June); Missaukee Co. (34 ♂, 4 ♀) (16 May-14 July); Monroe Co. (1 ♂, 1 ♀) (26 June); Montmorency Co. (13 ♂, 3 ♀) (28 June-7 July); Muskegon Co. (6 ♂) (26 June-1 July); Oakland Co. (18 ♂, 5 ♀) (22 May-26 June); Ogemaw Co. (1 ♂) (26 June); Oscoda Co. (3 ♂, 1 ♀) (23-25 June); Otsego Co. (8 ♂, 5 ♀) (24 June-5 July); Presque Isle Co. (9 ♂, 3 ♀) (13 June-3 July); Roscommon Co. (4 ♂, 2 ♀) (28 June); Schoolcraft Co. (5 ♂, 5 ♀) (2 June-16 July); Shiawasee Co. (2 ♂, 1 ♀) (6 June); St. Joseph Co. (1 ♂, 2 ♀) (15 May); Washtenaw Co. (22 ♂, 12 ♀) (11 May-16 June); Wayne Co. (1 ♀) (no date). Minnesota: Anoka Co. (1 ♀) (13 June); Beltrami Co. (2 ♀) (16 June); Cass Co. (2 ♂) (8-15 June); Hennepin Co. (1 ♂, 3 ♀) (4 June-17 July); Hubbard Co. (2 ♂) (5 June); Itasca Co. (11 ♂, 7 ♀) (29 May-16 June); Ramsey Co. (9 ♂, 2 ♀) (4 June-10 July); St. Louis Co. (3 ♂, 3 ♀) (21 May); Wabasha Co. (2 ♂) (22 June-18 July). New Hampshire: Carroll Co. (4 ♂) (19 June-12 July); Cheshire Co. (1 ♂) (June); Grafton Co. (2 ♂, 1 ♀) (no date). New Jersey: Bergen Co. (1 ♂) (no date); Morris Co. (3 ♂, 1 ♀) (28 May-22 June); Ocean Co. (2 ♂) (6 June); Sussex Co. (1 ♂) (31 May). New York: Duchess Co. (1 ♂) (22 May); Essex Co. (4 ♂) (9 July); Franklin Co. (3 ♂, 2 ♀) (16 June-25 July); Greene Co. (1 ♂, 1 ♀) (28 May); Herkimer Co. (1 ♂, 1 ♀) (26 June); Hudson Co. (1 ♂, 1 ♀) (no date); Monroe Co. (1 ♂) (15 June); Nassau Co. (8 ♂, 2 ♀) (26 June); Onondaga Co. (2 ♂, 2 ♀) (7-15 June); Orange Co. (1 ♂, 1 ♀) (9 July); St. Lawrence Co. (1 ♀) (19 June); Tioga Co. (1 ♂) (4 July); Tompkins Co. (2 ♀) (no date); Warren Co. (6 ♂, 3 ♀) (July); Washington Co. (1 ♂) (16 July). Ohio:

Williams Co. (4 ♂) (30 May). PENNSYLVANIA: Northampton Co. (2 ♂) (10 June). VERMONT: Caledonia Co. (1 ♂) (16 July). WASHINGTON: Spokane Co. (1 ♂) (4 July); Thurston Co. (1 ♀) (no date). WISCONSIN: Ashland Co. (1 ♀) (3 June).

In addition to the above material, the following Canadian material was examined. These localities are not included on the distribution map (Fig. 1). BRITISH COLUMBIA: Vancouver Island (2 ♂, 2 ♀) (7-19 July); Nanino, Langford Lake (2 ♂) (20 July). NEW BRUNSWICK: St. John's (1 ♀) (18 June). NOVA SCOTIA: Hants, Mt. Uniacke (2 ♂, 4 ♀) (no date); Shelburne, Allendale (1 ♂) (no date). ONTARIO: Thunder Bay District: Fort Williams (7 ♂, 2 ♀) (25 June); Orient Bay (11 ♂, 4 ♀) (22 June); Silver Inlet (2 ♂, 1 ♀) (12-19 July). Nipissing District: Go Home Bay (1 ♂) (19 June); Cochrane (2 ♂) (no date); North Bay (2 ♂) (no date). QUEBEC: Angenteuill, Newago (2 ♀) (no date).

Libellula (*Ladona*) *deplanata* Rambur

Libellula deplanata Rambur, 1842, Histoire Naturelle des Insectes, Neuroptères, pp. 75-76; Hagen, 1861, Synopsis of Neuroptera of North America, p. 154; Hagen, 1875, Proc. Boston Soc. Nat. Hist., vol. 18, p. 69; Kirby, 1890, Synoptic Catalogue of Neuroptera-Odonata, p. 26; Calvert, 1893, Trans. American Ent. Soc., vol. 208, p. 258; Williamson, 1900, Rpt. Indiana Dept. Geol., vol. 24, p. 331; Osborn, 1905, Ent. News, vol. 16, p. 195; Muttkowski, 1908, Bull. Wisconsin Soc. Nat. Hist., vol. 6, p. 115; Calvert, 1912, Ent. News, vol. 23, p. 484; Weiss, 1915, Ent. News, vol. 26, p. 102; Byers, 1927, Ent. News, vol. 38, p. 114; Byers, 1928, Ent. News, vol. 39, p. 230; Byers, 1930, Univ. Florida Pub. Biol. Sci., vol. 1, pp. 13, 26, 38, 107, 110-112, 117, 121, 232, 261, 275, 299; Williamson, 1931, Ent. News, vol. 42, p. 149; Montgomery, 1940, Jour. Mitchell Soc., vol. 56, p. 292.

Ladona deplanata; Needham, 1897, Canadian Ent., vol. 29, pp. 141-146; Needham, 1901, Bull. New York St. Mus., vol. 47, pp. 528-530; Brimley, 1908, Ent. News, vol. 17, p. 135; Brimley, 1918, Ent. News, vol. 29, p. 229; Needham and Heywood, 1929, Handbook of North American Dragonflies, p. 217; Brimley, 1938, Insects of North Carolina, p. 39; Montgomery, 1940, Jour. Mitchell Soc., vol. 56, p. 292; Bick, 1950, American Midl. Nat., vol. 43, p. 73; Westfall, 1953, Florida Ent., vol. 36, p. 171; Montgomery, 1955, Proc. Indiana Acad. Sci., vol. 64, p. 134; Needham and Westfall, 1955, Dragonflies of North America, pp. 58, 474, 476, 477.

Libellula (*Ladona*) *deplanata;* Borror, 1945, Ann. Ent. Soc. Amer., vol. 38, p. 192; Cook, 1951, Ent. News, vol. 62, p. 187; Kennedy, 1922, Ent. News, vol. 38, pp. 69, 110-111; Ris, 1910, Coll. de Selys, vol. 11, p. 258.

TYPES. Male holotype and female allotype in the Selys Collection, Institut Royal d'Histoire Naturelle de Belgique, Brussels, Belgium. Holotype with thorax damaged dorsally, left forewing broken and lost at level of second antenodal crossvein and proximal side of triangle; shows signs of repair on thorax, glue on legs and one spot on wings. Allotype with much of thorax gone on left side, all legs gone, right forewing broken and lost at nodus.

Male. Measurements: Total length, 33.0 ± 1.469 mm. (holotype 30.0 mm.); abdomen length, 21.6 ± 1.608 mm. (holotype 18.0 mm., appendages missing); forewing length, 24.10 ± 1.742 mm. (holotype 25.5 mm.); hind wing length, 23.70 ± 1.625 mm. (holotype 25.0 mm.); stigma length, 3.10 ± .622 mm. (holotype 3.0 mm.); length nodus to stigma, 8.95 ± .267 mm. (holotype 9.0 mm.); metathoracic femur length, 5.22 ± .718 mm. (holotype 4.0 mm.); prothoracic tibia length, 3.45 ± .444 mm. (holotype 4.0 mm.); mesothoracic tibia length, 4.02 ± .486 mm. (holotype 4.0 mm.); metathoracic tibia length, 5.03 ± .179 mm. (holotype 4.0 mm.); head width, 5.96 ± .720 mm. (holotype 5.5 mm.); superior anal appendage length, 1.68 ± .276 mm.; supra-anal plate length, 1.24 ± .377 mm.

Head with parietal region of cranium brown; compound eyes tan or brown; vertex black with punctate appearance; ocelli surrounded by yellow margin; frons uniformly light tan, darkening with age; epistomal suture a colorless groove arched somewhat dorsally; postclypeus uniform light tan like frons; anteclypeus slightly darker than frons; labrum yellow, becoming slightly darker toward median depression; labium tan to yellow, median lobe darkening with age.

Prothorax with dorsal margin of anterior lobe gold, remainder brown; middle lobe tan to light brown with median ridge bearing two dorsolateral dark brown spots; posterior lobe light tan to brown, occasionally darkening with age; dorsal lobe of eucervicale gold with occasional dark patches posteriorly.

Synthorax with acrotergite II, mesostigmal plate, area posterior to pit of tergal apophysis II, and collar carina black; dorsal carina light brown; antealar carina light brown; antealar sinus light tan or brown; anepisternum II dorsally with mesal brown region bordered on each side by broad cream antehumeral stripe, darkening with age to blue-black; anepisternum II laterally with upper half cream, lower half dark brown; katepisternum II uniform light brown; mesopleural suture forming deep groove dorsally; epimeron II uniform light brown; anepisternum III tan; epimeron III light brown; metapleural suture dorsally a deep groove surrounded by dark brown area, remainder paler.

Forewings with subcostal-radial and medial interspace dark brown to level of second antenodal crossvein; radial and medial-postcubital interspace without coloration; postcubital-anal interspace with faint and irregular light brown extending approximately

half way to anal crossing; stigma light brown, subtending two to three cells; antenodal crossveins 10 to 12; postnodal crossveins 8 to 11. Hind wings with subcostal-radial and medial interspace dark brown to level of fourth or fifth antenodal crossvein; radial and medial-postcubital interspace without coloration; postcubital-anal interspace dark brown to middle of triangle; first anal interspace with small irregular dark brown triangle; stigma light brown, subtending two to three cells; antenodal crossveins 9 to 10; postnodal crossveins 9 to 11 (Fig. 9).

Legs with femora and tibiae uniformly light tan to brown, bearing small dark brown spots at distal ends of femora; tarsi uniformly dark brown to black.

Abdomen with segment I dark brown dorsally, light tan laterally and ventrally; segment II dorsally tan to light brown with anterior band of dark brown and with a dorsal dark brown triangular spot, laterally and ventrally tan to light brown; segment III dorsally tan to light brown with dorsal mesal light brown stripe becoming wide and black posteriorly, laterally tan with dorsal margin dark, becoming black and wider posteriorly, ventrally light tan; segments IV-VIII uniform with dorsal black stripe becoming wider posteriorly in each segment to form a black triangle, laterally with black dorsal region becoming wider posteriorly, with remainder of lateral surface tan bearing black on ventral margin; segment IX dorsally uniform black, laterally tan without black marking on ventral margin, ventrally tan; segment X dorsally light brown with irregular mesal black area, laterally light brown, ventrally tan; posterior ventral margin straight; supplementary transverse carinae shiny black, sinuate; posterior transverse carinae shiny black; submarginal transverse carinae shiny black; ventral carinae tan, occasionally becoming darker with age; acrotergites gray.

Superior anal appendage brown to black; inferior anal lamina not widely separated.

Penis with stem constricted, posterior projection sharply pointed; posterior margin of middle segment angular; distal segment a somewhat narrow pedicel; cornula sharply pointed (Fig. 4).

Posterior hamulus bifurcated with anterior process bearing a single laterally directed hook; lateral lobe broadly rounded (Fig. 5).

FEMALE. Measurements: Total length, 31.8 ± 1.894 mm. (allotype 30.0 mm.); abdomen length, 19.7 ± 1.728 mm. (allotype 18.5 + mm.); forewing length, 24.0 ± 1.413 mm. (allotype 26.5 mm.); hind wing length, 23.0 ± 1.412 mm. (allotype 24.0 mm.); stigma

length, 3.33 ± .506 mm. (allotype 3.0 mm.); length nodus to stigma, 8.65 ± .332 mm. (allotype 9.0 mm.); metathoracic femur length, 5.05 ± .764 mm.; prothoracic tibia length, 3.43 ± .636 mm.; mesothoracic tibia length, 3.99 ± .323 mm.; metathoracic tibia length, 5.01 ± .366 mm.; head width, 5.87 ± .383 mm. (allotype 5.0 mm.); superior anal appendage length, .76 ± .171 mm.

Head with parietal region of cranium light brown; compound eyes as male; vertex shiny black; ocelli with or without light yellow margin; frons yellow to orange; epistomal suture a slightly arched groove; postclypeus light brown with occasional yellow markings on ventral margin; anteclypeus as postclypeus; labrum yellow with irregular brown markings mesally; labium medium yellow with irregular brown markings on lateral portion of lateral lobes, darkening with age.

Prothorax with dorsal margin of dorsal lobe gold, remainder black; middle lobe tan to yellow with irregular black lateral markings; posterior lobe light brown with blue-black lateral markings; dorsal lobe of eucervicale yellow becoming brown posteriorly.

Synthorax with acrotergite II and mesostigmal plate blue-black; area posterior to pit of tergal apophysis II brown to black; collar carina brown, dorsal carina yellow; antealar carina light tan becoming black posteriorly; antealar sinus brown; anepisternum II dorsally and laterally as in male; katepisternum II greenish gray to olive; mesopleural suture forming deep groove dorsally and ventrally, surrounded by darkened areas; epimeron II greenish gray to olive; interpleural suture as a faint line; anepisternum III and katepisternum III greenish gray to olive; epimeron III greenish gray to olive with posterior traces of brown; metapleural suture deepened to form groove dorsally and ventrally. Coloration of lateral synthorax may become obscured with age due to irregular patches of blue-black coloration.

Forewing with costal-subcostal interspace clear; subcostal-radial and medial interspace dark brown to level of second antenodal crossvein; radial and medial-postcubital interspace clear; postcubital-anal interspace with very light translucent brown extending about half way to anal crossing; stigma tan, subtending two to three cells; antenodal crossveins 11 to 13; postnodal crossveins 8 to 10. Hind wing with costal-subcostal interspace clear; subcostal-radial and medial interspace dark brown to level of second or third antenodal crossvein; radial and medial-postcubital interspace clear; postcubital-anal interspace dark brown to triangle; first anal

interspace with very small black triangle covering three to four cells; stigma tan, subtending two to three cells; antenodal crossveins 9 to 10; postnodal crossveins 8 to 10.

Legs with coxae and femora dark brown or tan with black areas at distal ends of femora; tibiae light tan; tarsi dark brown to black.

Abdomen with segment I dorsally black, laterally and ventrally tan; segments II-X as in male. In both males and females of *deplanata,* there is occasionally a general darkening of the abdomen with age.

Anal appendage brown to black, elongate with broadly rounded apex, shorter than segment X; supra-anal plate tan to brown, more sharply rounded at apex than in *julia,* shorter than anal appendage.

NYMPH. Total length, 18-20 mm.; mentum with median projection less prominent than in *julia;* no mental setae present; dorsal abdominal hooks overlapping half or more of following segment; length of anal appendages 3.0 mm., of abdominal segments IX-X 2.0 mm.

BIONOMICS. Needham and Heywood (1929) indicated that this species is found flying about the edges or slightly over the open water of ponds. They also reported this species as having a slow, irregular flight and being easy to capture. Montgomery (1953) observed this species to fly with fluttering motions over bare areas along the shore, alighting on bare ground in a manner reminiscent of *Plathemis lydia.* However, Montgomery points out that *deplanata* is less active than *lydia* and does not fly rapidly along the lake margins as does *lydia.* Bick (1957) observed this species flying swiftly, approximately three feet above the water. He also observed *deplanata* perched on the ground, not more than twenty feet from the water's edge. He states that this species occurs in pinelands, near lentic waters including sloughs, ponds, and borrow pits. Bick (1950) records having taken nymphs of this species from mud bottomed roadside borrow pits with heavy vegetation. He found the nymphs of *deplanata* associated with *Tetragoneuria cynosura, Libellula lydia, Libellula luctuosa, Pachidiplax longipennis,* and *Erythemis simplicicollis.*

The more northern specimens of this species show a considerable darkening of most features of the color pattern. The synthorax tends to become blue-black and the antehumeral stripes less readily visible. The southern specimens were found to agree more with the type than those in the northern portion of the range. Due to these differences between the specimens from Florida and more

northern localities, there is some justification for subspecific rank for the more northern forms. However, due to the paucity of northern specimens and absence of material from intervening regions, I do not feel it advisable to attach formal names to the geographical variants at the present time.

Distribution. Type locality: "North America." Alabama: Baldwin Co. (1 ♂, 1 ♀) (11 April). Florida: Alachua Co. (10 ♂, 21 ♀) (15 March-3 April); Brevard Co. (1 ♀) (2 March); Lee Co. (1 ♂, 1 ♀) (21 March-3 April); Gadsden Co. (1 ♀) (8 April); Gulf Co. (4 ♂, 8 ♀) (25 March-12 April); Highlands Co. (8 ♂, 13 ♀) (12 Feb.-20 March); Hillsboro Co. (2 ♀) (12 Feb.-8 March); Leon Co. (5 ♂, 5 ♀) (23 March); Madison Co. (2 ♂, 2 ♀) (6 April); Okeechobee Co. (1 ♂, 2 ♀) (18 Feb.); Orange Co. (20 ♂, 17 ♀) (1 Jan.-10 Dec.); Osceola Co. (2 ♂, 14 ♀) (23 Feb.-22 March); Palm Beach Co. (1 ♀) (24 Feb.); Pinellas Co. (1 ♂, 2 ♀) (4 April); Sarasota Co. (2 ♀) (—Feb.-1 April); Seminole Co. (11 ♂, 8 ♀) (14 Jan.-5 March); Suwannee Co. (1 ♀) (28 April); Volusia Co. (5 ♂, 4 ♀) (22 April); Wakulla Co. (2 ♂) (1 April). Indiana: Clark Co. (12 ♂, 31 ♀) (11-12 June). Louisiana: Union Parish (1 ♂) (1 April); St. Tammany Parish (1 ♀) (9 April). Mississippi: George Co. (1 ♂, 1 ♀) (10-26 April); Harrison Co. (1 ♂) (10 April). North Carolina: Craven Co. (2 ♀) (14 May). Oklahoma: Pushmataha Co. (1 ♂) (28 March).

Libellula (*Ladona*) *exusta* Say

Libellula exusta Say, 1839, Jour. Acad. Nat. Sci., Philadelphia, vol. 8, pp. 29-30; Hagen, 1861, Synopsis of Neuroptera of North America, p. 115; Hagen, 1873, Proc. Boston Soc. Nat. Hist., vol. 16, p. 361; Kirby, 1890, Synoptic Catalogue of Neuroptera-Odonata, p. 26; Wadsworth, 1890, Ent. News, vol. 1, p. 56; Harvey, 1891, Ent. News, vol. 2, p. 4; Hitchings, 1892, Ent. News, vol. 3, p. 39; Calvert, 1893, Trans. American Ent. Soc., vol. 20, pp. 152, 258; Calvert, 1895, Jour. New York Ent. Soc., vol. 3, p. 47; Goddard, 1896, Proc. American Philos. Soc., vol. 35, p. 209; Calvert, 1897, Jour. New York Ent. Soc., vol. 5, p. 47; Harvey, 1898, Ent. News, vol. 9, p. 87; Hine, 1899, Ann. Rpt. Ohio Acad. Sci., vol. 7, p. 66; Kellicott, 1899, Special Pub. Ohio Acad. Sci., vol. 2, p. 99; Burnham, 1900, Proc. Manchester (N. H.) Inst. Art. Sci., vol. 1, p. 35; Osburn and Hine, 1900, Ohio Nat., vol. 1, p. 14; Weith, 1900, Ent. News, vol. 11, p. 641; Williamson, 1900, Rpt. Indiana Dept. Geol., vol. 24, pp. 327, 328, 331; Williamson, 1900, Proc. Indiana Acad. Sci., vol. 24, p. 173; Calvert, 1900, Rpt. New Jersey Board Agric., vol. 27, p. 8; Burnham, 1901, Proc. Manchester (N. H.) Inst. Art. Sci., vol. 2, p. 44; Harvey, 1902, Ent. News, vol. 13, p. 10; Brimley and Sherman, 1904, Ent. News, vol. 15, p. 101; Calvert, 1905, Occ. Pub. Boston Soc. Nat. Hist., vol. 7, p. 34; Osborn, 1905, Ent. News, vol. 16, pp. 186, 195, 196; Williamson, 1907, Ohio Nat., vol. 7, p. 105; Muttkowski, 1908, Bull. Wisconsin Nat. Hist. Soc., vol. 6, p. 116; Walker, 1908, Ottawa Nat., vol. 22, p. 23; Wilson, 1909, Proc. United States Nat. Mus., vol. 36, pp. 655, 657, 658, 670; Calvert, 1910, Rpt. New Jersey State Mus., 1909, p. 80; Davis, 1913, Jour. New York

Ent. Soc., vol. 21, p. 24; Whedon, 1914, Rpt. Minnesota St. Ent., vol. 15, p. 98; Woodruff, 1914, Jour. New York Ent. Soc., vol. 22, p. 158; Walker, 1915, Rpt. Ontario Dept. Fish., vol. 47 (supplement), pp. 58, 60; Hankinson, 1916, Pub. Michigan Geol. Sur., vol. 20, p. 117; Howe, 1916, Univ. Michigan Mus. Zool., Occ. Pap., no. 41, p. 8; Howe, 1917, Psyche, vol. 24, p. 51; Williamson, 1917, Misc. Pub. Univ. Michigan Mus. Zool., vol. 2, p. 10; Howe, 1919, Canadian Ent., vol. 51, p. 14; Howe, 1919, Ent. News, vol. 30, p. 13; Howe, 1919, Psyche, vol. 26, p. 67; Howe, 1920, Psyche, vol. 27, p. 57; Howe, 1920, Mem. Thoreau Mus., vol. 2, pp. 67, 71, 97, 101; Howe, 1921, Proc. Boston Soc. Nat. Hist., vol. 36, pp. 114, 115, 128; Howe, 1921, Mem. Thoreau Mus., vol. 2 (supplement), p. 10; Williamson, 1921, Ent. News, vol. 32, p. 22; Byers, 1925, Pub. Michigan Acad. Sci., vol. 5, pp. 393, 396; Byers, 1927, Ent. News, vol. 38, p. 114; Byers, 1927, Univ. Michigan Mus. Zool., Occ. Pap., no. 183, p. 11; Kennedy, 1928, Ecology, vol. 9, p. 375; Byers, 1930, Univ. Florida Pub. Biol. Sci., vol. 1, pp. 111-112; Walker, 1934, Proc. Nova Scotia Inst. Sci., vol. 18, p. 126; Borror, 1940, Ent. News, vol. 51, p. 78; Walker, 1942, Proc. Nova Scotia Inst. Sci., vol. 20, p. 174.

Ladona exusta; Needham, 1897, Canadian Ent., vol. 29, pp. 145-146; Needham, 1901, Bull. New York St. Mus., vol. 47, p. 528; Needham, 1908, Rpt. Michigan Geol. Sur., 1907, p. 264; Muttkowski, 1910, Bull. Wisconsin Nat. Hist. Soc., vol. 8, p. 57; Needham and Heywood, 1929, Handbook of Dragonflies of North America, pp. 217, 218, 226; Borror, 1935, Ohio Jour. Sci., vol. 35, p. 454; Wright, 1937, Jour. Tennessee Acad. Sci., vol. 12, p. 260; Wright, 1939, Jour. Tennessee Acad. Sci., vol. 14, p. 207; Wright, 1943, Jour. Tennessee Acad. Sci., vol. 18, p. 189; Needham and Westfall, 1955, Dragonflies of North America, pp. 58, 474, 476, 477; Kormondy, 1959, Misc. Pub. Univ. Michigan Mus. Zool., no. 104, p. 34.

Libellula (*Ladona*) *exusta;* Borror, 1945, Ann. Ent. Soc. Amer., vol. 38, p. 192; Kennedy, 1922, Ent. News, vol. 33, p. 111; Ris, 1910, Coll. de Selys, vol. 11, pp. 247, 256-259.

TYPES. Male holotype located in Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts.

MALE. Measurements: Total length, 36.8 ± 1.894 mm. (holotype 39.4 mm.); abdomen length, 23.4 ± 1.435 mm. (holotype 24.8 mm.); forewing length, 27.8 ± 1.316 mm. (holotype 33.0 mm.); hind wing length, 26.8 ± 1.316 mm. (holotype 31.2 mm.); stigma length, 2.91 ± .423 mm. (holotype 3.2 mm.); length nodus to stigma, 10.04 ± .610 mm. (holotype 11.2 mm.); metathoracic femur, 5.75 ± 1.00 mm. (holotype 8.0 mm.); prothoracic tibia length, 3.68 ± .806 mm.; mesothoracic tibia length, 4.21 ± .655 mm.; metathoracic tibia length, 5.62 ± .806 mm. (holotype 6.6 mm.); head width, 6.15 ± .948 mm. (holotype 6.7 mm.); superior anal appendage length, 1.57 ± .236 mm. (holotype about 2.0 mm.); supra-anal appendage length, 1.13 ± .212 mm. (holotype about 1.0 mm.).

Head with parietal region of cranium light brown, darkening with age; compound eyes reddish brown; vertex with dorsal two-thirds yellowish tan to olive, ventral one-third brown; ocelli surrounded by yellow band; antenna black; frons light tan to olive, darkening laterally; epistomal suture an arched groove; postclypeus

tan to dark brown; anteclypeus like frons in color; labrum tan to dark brown; labium colored like labrum, darkening to black with age.

Prothorax with anterior lobe light yellow to gold, bearing irregular central brown markings; middle lobe light brown becoming darker mesally, median ridge brown with white hairs; posterior lobe brown becoming darker posteriorly, sometimes becoming black with age; dorsal lobe of eucervicale uniform gold to yellow, darkening with age.

Synthorax with acrotergite II black becoming light tan laterally; mesostigmal plates yellow to light brown; area posterior to pit of tergal apophysis II tan to light brown with irregular mesal markings of darker brown; collar carina light brown; dorsal carina blue-black; antealar carina tan becoming shiny black posteriorly; antealar sinus tan; anepisternum II dorsally brown bordered by antehumeral stripes of yellow-gray, darkening to black with age; anepisternum II laterally with upper half yellow-gray to cream, lower half dark brown; katepisternum II brown, darkening with age; mesopleural suture deepened dorsally and ventrally; epimeron II brown; anepisternum III brown; katepisternum III brown; epimeron III brown; metapleural suture deepened dorsally and ventrally.

Forewing with subcostal-radial and medial interspace dark brown to level of fourth antenodal crossvein; radial and medial-postcubital interspace light translucent brown to arculus; postcubital-anal interspace dark brown to anal crossing or slightly beyond; stigma light tan, subtending two to three cells; antenodal crossveins 11 to 14; postnodal crossveins 9 to 13. Hind wing with subcostal-radial and medial interspace dark brown to level of fifth or sixth antenodal crossvein; radial and medial-postcubital interspace light translucent brown to level of fifth or sixth antenodal crossvein; postcubital-anal interspace dark brown to anal crossing or slightly beyond; first anal interspace with dark brown triangle; stigma tan, subtending two to three cells; antenodal crossveins 9 to 12; postnodal crossveins 10 to 12 (Fig. 10).

Legs with femora and tibiae undifferentiated light tan, becoming brown to black with age; tarsi brown.

Abdomen with segment I dorsally olive to light tan, laterally and ventrally light brown; segments II-IX in young males dorsally and laterally dull white with blue-black traces, in mature males black; all carinae tan except black dorsal and posterior transverse

carinae, ventral aspect of segments tan, these segments darkening to black with occasional irregular pale areas remaining, all carinae with exception of ventral carina becoming shiny black; segment X light tan with concave ventral posterior margin.

Superior anal appendage brown to black, darkening with age; inferior anal lamina not widely separated.

Penis without constricted stem, posterior projection broadly rounded; posterior margin of middle segment angular; distal segment a broad pedicel; cornula broadly rounded at each end (Fig. 6).

Posterior hamuli bifurcate with anterior process bearing two laterally directed hooks; lateral lobe bluntly rounded (Fig. 7).

FEMALE. Measurements: Total length, 33.2 ± 1.447 mm.; abdomen length, 20.8 ± 1.707 mm.; hind wing length 24.8 ± 1.600 mm.; forewing length, 25.8 ± 1.927 mm.; stigma length, 3.33 ± .547 mm.; length nodus to stigma, 9.76 ± .387 mm.; metathoracic femur length, 5.63 ± .788 mm.; prothoracic tibia length, 3.64 ± .572 mm.; mesothoracic tibia length, 4.05 ± .526 mm.; metathoracic tibia length, 5.59 ± .726 mm.; head width, 5.91 ± .924 mm.; superior anal appendage length, .85 ± .179 mm.

Head with parietal region tan; compound eyes reddish brown; vertex with dorsal two-thirds reddish brown, ventral one-third black; ocelli surrounded by yellow band; frons tan to olive; epistomal suture an arched groove; postclypeus as frons; anteclypeus as frons; labrum yellowish, darkening mesally; labium colored like labrum with occasional irregular black markings.

Prothorax with anterior lobe black bearing lateral yellow spots; middle lobe brown becoming darker mesally; posterior lobe light brown to black; dorsal lobe of eucervicale gold.

Synthorax with acrotergite II black becoming light brown laterally; mesostigmal plate tan, area posterior to pit of tergal apophysis II black becoming light brown laterally; collar carina tan; dorsal carina black; antealar carina anteriorly brown becoming black posteriorly; antealar sinus tan; anepisternum II dorsally light brown, bordered laterally by gray antehumeral stripe; anepisternum II laterally with upper one-third gray, middle one-third dark brown, remainder medium brown; katepisternum II medium brown; mesopleural suture deepened dorsally and ventrally forming deep grooves surrounded by blue-black areas; epimeron II, anepisternum III, katepisternum III, epimeron III medium brown

as katepisternum II, showing irregular darkening with age; interpleural suture as a faint groove; metapleural suture deepened dorsally and ventrally, markedly so ventrally.

Forewing with costal-subcostal interspace with irregular translucent brown to level of second antenodal crossvein; subcostal-radial and medial interspace dark brown to level of fourth or fifth antenodal crossvein; radial and medial-postcubital interspace translucent brown to arculus or slightly beyond; postcubital-anal interspace dark brown to level of arculus or slightly beyond; stigma yellow to light tan, subtending two to three cells; antenodal crossveins 10 to 14; postnodal crossveins 8 to 10. Hind wing with costal-subcostal interspace as in forewing; subcostal-radial and medial interspace dark brown to level of sixth or seventh antenodal crossvein; radial and medial-postcubital interspace translucent brown to level of sixth or seventh antenodal crossvein; postcubital-anal interspace dark brown to middle of triangle; first anal interspace with dark brown triangle; stigma as forewing, subtending two to three cells; antenodal crossveins 9 to 11; postnodal crossveins 8 to 12.

Legs with femora light brown; tibiae light tan to light brown; tarsi brown, slightly darker than tibia.

Abdomen with segment I dorsally black becoming brown laterally and ventrally; segment II dorsally and laterally dark brown with traces of black, ventrally light tan to light brown; segment III dorsally and laterally dark dull brown with irregular black, ventrally light brown; segments IV-IX with regular black stripe dorsally, laterally dark dull brown with dorsal and ventral black stripes, occasional irregular black, ventrally dark brown; segment X dark, almost black dorsally, brown ventrally; supplementary carinae shiny tan; posterior transverse carinae brown; submarginal ventral carinae black; ventral carinae brown; acrotergites and antecostal sutures brown to black.

Anal appendages as in *deplanata*.

Nymph. Unknown.

Bionomics. Evidently no biological data in literature.

Distribution. Type locality: "Massachusetts." Connecticut: Litchfield Co. (10 ♂, 2 ♀) (20 June). Maine: Androscoggin Co. (3 ♀) (21 June); Aroostock Co. (3 ♀) (30 May-18 June); Kennebec Co. (5 ♂, 7 ♀) (11 June-5 July); Lincoln Co. (22 ♂, 28 ♀) (9 June-28 July); Penobscot Co. (1 ♂) (12 July); Piscataquis Co.

(3 ♀) (6 April). NEW HAMPSHIRE: Carroll Co. (1 ♀) (28 July). NEW JERSEY: Burlington Co. (1 ♂, 3 ♀) (6-10 June); Camden Co. (1 ♂, 1 ♀) (20 May); Middlesex Co. (1 ♀) (5 June); Ocean Co. (2 ♂, 16 ♀) (2 May-3 July). MASSACHUSETTS: Barnstable Co. (11 ♂) (10 June-1 July); Hampden Co. (1 ♂) (20 June); Middlesex Co. (1 ♀) (21 June); Worcester Co. (1 ♂) (18 June). NEW YORK: Essex Co. (2 ♀) (4 July). VERMONT: Windham Co. (2 ♀) (30 April).

In addition to the above material, the following specimens were examined from Canada. NOVA SCOTIA: Hants, Mt. Uniacke (2 ♂, 3 ♀) (20 June).

VARIATIONS IN LIBELLULA (LADONA) JULIA

With a few notable exceptions, the taxonomy of Odonata has progressed little beyond the alpha level because the field as a whole has been slow in accepting modern systematic methods. For this reason, the species limits are somewhat poorly defined, and infraspecific variation is rarely considered. A large sample of *L.* (*L.*) *julia,* the most widespread species, was available for a study of color variation and certain other characters.

I. COLOR VARIATION

Coloration has been used extensively in dragonfly taxonomy; however, too frequently color determination has been based on specimens representing only a limited portion of the total range of color.

A. Coloration of the head. The color patterns of the head were found to be quite variable, with all the colors studied tending to become darker with age. The parietal region exhibits some variation in the amount of peripheral darkening. The frons varies considerably in the amount of darkening, with the central portion showing all gradations from light tan or cream to black. The labrum varies only slightly from tan or orange to very light brown. The most variable structure with regard to color is the labium, which ranges from orange to black. This variation is believed to be at least partially due to age differences and hence of no taxonomic value.

B. Coloration of the prothorax. Little variation was found in the coloration of the dorsal aspects of the anterior, middle, and posterior lobes of the prothorax, and if care is exercised in the de-

scription they should prove reliable as taxonomic characters. The coloration of the lateral sclerites, especially the eucervicale, is quite variable with regard to its gold or yellow coloration and is of greatly reduced taxonomic value.

C. Coloration of the synthorax. The coloration of the dorsum of anepisternum II is of considerable taxonomic value in many dragonfly groups. However, this structure tends to darken with age and shows geographic variation, becoming slightly darker northward. In spite of these differences, these color patterns were found to provide excellent specific characters.

D. Coloration of the abdomen. Segment I is uniformly light brown to tan, exhibiting little variation. Segments II through IV are typically white on their dorsal and lateral aspects. This color pattern is quite reliable over the entire range of the species, with the exception of several specimens in which the white pattern had become considerably darkened with age. The remaining abdominal segments show considerable variation with regard to lateral coloration. The lateral surface of each segment usually has an irregular light brown spot on the ventral portion. In many specimens these segments are wholly black. The anal appendages vary from light brown to black, with no regular pattern.

No distinct geographic variation of color patterns was observed in *julia.* In general, however, there was observed a gradual darkening trend of coloration in the more northern specimens examined. This general northward darkening of colors is slight and does not readily lend itself to quantification. In addition, there is a slight extension of the coloration in the wings of the more northern specimens. This was especially noted in the extent of coloration in the subcostal-radial and medial regions. In southern forms, coloration usually extends to the level of the second antenodal crossvein, whereas in more northern forms it usually extends to the level of the third antenodal crossvein, rarely only to the second.

A similar color trend has been reported by Kormondy (1959) for the genus *Tetragoneuria.* He subjected last-instar nymphs to reduced temperatures for ten weeks, and the emerging adults showed a darkening of body and hindwing coloration. Petersen (1949) found a similar condition in certain Fennoscandian butterflies. It is likely that the northern darkening is a condition directly related to climate.

II. Size Variation

For a study of variation in size, thirteen characters (see Techniques and Terminology section) were chosen and measured on 360 males of *julia*. The mean ($\bar{X}$), standard error of the mean (S. E. $\bar{X}$.), standard deviation (S. D.), standard error of the standard deviation (S. E. S. D.), the coefficient of variation (C. V.), and the standard error of the coefficient of variation (S. E. C. V.) were determined for each of five populations, as discussed below. Standard statistical techniques were utilized (Simpson, Roe, and Lewontin, 1960).

The total sample was divided into five subgroups or populations. These subgroups were separated with consideration of climatic and ecological areas and at the same time with the need in mind that the subsamples must have adequate size for statistical purposes. The geographic areas comprising each such population are indicated below. The numbers in parentheses indicate the number of male specimens from each locality (see insert map, Fig. 1).

Population I: MAINE—Kennebec Co. (1), Lincoln Co. (24); NEW HAMPSHIRE—Carroll Co. (8), Grafton Co. (2); VERMONT—Caledonia Co. (1).

Population II: CONNECTICUT—Litchfield Co. (6), Tolland Co. (17); MASSACHUSETTS—Barnstable Co. (1), Hampden Co. (3), Middlesex Co. (9), Norfolk Co. (5), Worcester Co. (4); NEW HAMPSHIRE—Cheshire Co. (1); NEW JERSEY—Bergen Co. (1), Morris Co. (3), Ocean Co. (2), Sussex Co. (1); NEW YORK—Duchess Co. (1), Essex Co. (4), Franklin Co. (3), Greene Co. (1), Herkimer Co. (1), Monroe Co. (1), Onondaga Co. (2), Orange Co. (1), Tioga Co. (1), Warren Co. (5), Washington Co. (1).

Population III: INDIANA—Elkhart Co. (3), Wells Co. (1); MICHIGAN—Kent Co. (1), Livingston Co. (7), Monroe Co. (1), Muskegon Co. (6), Oakland Co. (18), St. Joseph Co. (1), Washtenaw Co. (21); OHIO—Williams Co. (4).

Population IV: MICHIGAN—Alger Co. (2), Baraga Co. (1), Charlevoix Co. (5), Cheboygan Co. (19), Chippewa Co. (2), Clare Co. (1), Dickinson Co. (1), Emmet Co. (2), Gladwin Co. (4), Gogebic Co. (1), Grand Traverse Co. (10), Houghton Co. (3), Iosco Co. (2), Iron Co. (3), Keweenaw Co. (7), Luce Co. (6), Mackinac Co. (12), Marquette Co. (5), Mason Co. (1), Menominee Co. (5), Midland Co. (1), Missaukee Co. (33), Mont-

morency Co. (11), Ogemaw Co. (1), Oscoda Co. (3), Otsego Co. (8), Presque Isle Co. (9), Roscommon Co. (4), Schoolcraft Co. (5).

Population V: Minnesota—Cass Co. (2), Hennepin Co. (1), Hubbard Co. (3), Itasca Co. (11), Ramsey Co. (8), St. Louis Co. (3), Wabasha Co. (2).

Certain of these measurements are presented in graphic form in Figures 11-14.

Most structures measured show relatively low coefficients of variation, ranging from 2.8283 for head width to 7.5783 for the inferior anal appendages. This indicates considerable stability of the characters measured. Therefore, these characters should prove quite reliable for taxonomic use (Simpson, Roe, and Lewontin, 1960).

The majority of the characters measured (front tibia, middle tibia, hind tibia, hind wing, abdomen, total length, superior anal appendage, and inferior anal appendage) exhibit two clinal trends (Fig. 11). All of these measurements show an increase from north to south. A second trend is the western increase of these measurements. The femur shows much the same variation as the head width, with the exception of a decrease in population II. Both length of forewing and nodus-stigma length exhibit somewhat irregular and discontinuous variation; however, both show much the same geographic trends, with the exception of population II. It is quite possible these characters are influenced by microenvironmental conditions more than the others.

The trend toward southern size increase has been reported several times. Petersen (1949), working with certain butterflies, found both longitudinal and latitudinal size variations of the same types as those exhibited by *julia.* Huggins (1929), in a study of *Calopteryx maculata,* found the same. The northward decrease in the length of the extremities has been known for some time in homoiothermal animals (Allen's rule). The same northward decrease in extremities is found in the comparison of populations I and II of *julia.* A similar case has been reported by Petersen (1949).

The increase in size for populations III, IV, and V, however, would also appear to accompany the reduction of temperature. Kormondy (1959), working with *Tetragoneuria,* has reported the same trends. Kormondy was able to show a correlation between

the mean annual temperature and length. He found that with each degree decrease in temperature there was an increase of about 0.08 mm. in the length of the front tibia.

Certainly temperature is not the only factor correlated with size change and does not explain the decrease in the majority of measurements found between populations I and II. The decrease of size in populations I and II has probably resulted from micro-environmental factors.

SUMMARY AND CONCLUSIONS

A study was undertaken to clarify the taxonomic position of *Ladona* and its three species. All three species are re-described on the basis of relatively large samples. Nymphs (unknown for one species) are also briefly re-described.

Considerable disagreement exists in the literature concerning the status of *Ladona*, which has been regarded as a genus by some authors, a subgenus by others, and a synonym of *Libellula* by still others. A study of various morphological features has convinced me that the subgeneric status is most appropriate.

A preliminary study of intraspecific variation was made on *Libellula* (*Ladona*) *julia*. Certain color patterns were found to be quite unreliable for taxonomic use. In general, coloration was found to exhibit a northward darkening trend, which is believed to be correlated with temperature.

All characters measured exhibited relatively low coefficients of variation and appear suitable for further use as taxonomic characters. Both latitudinal and longitudinal size variation with regard to various measurements was observed. An increase in size was seen in the more southern and western portions of the range.

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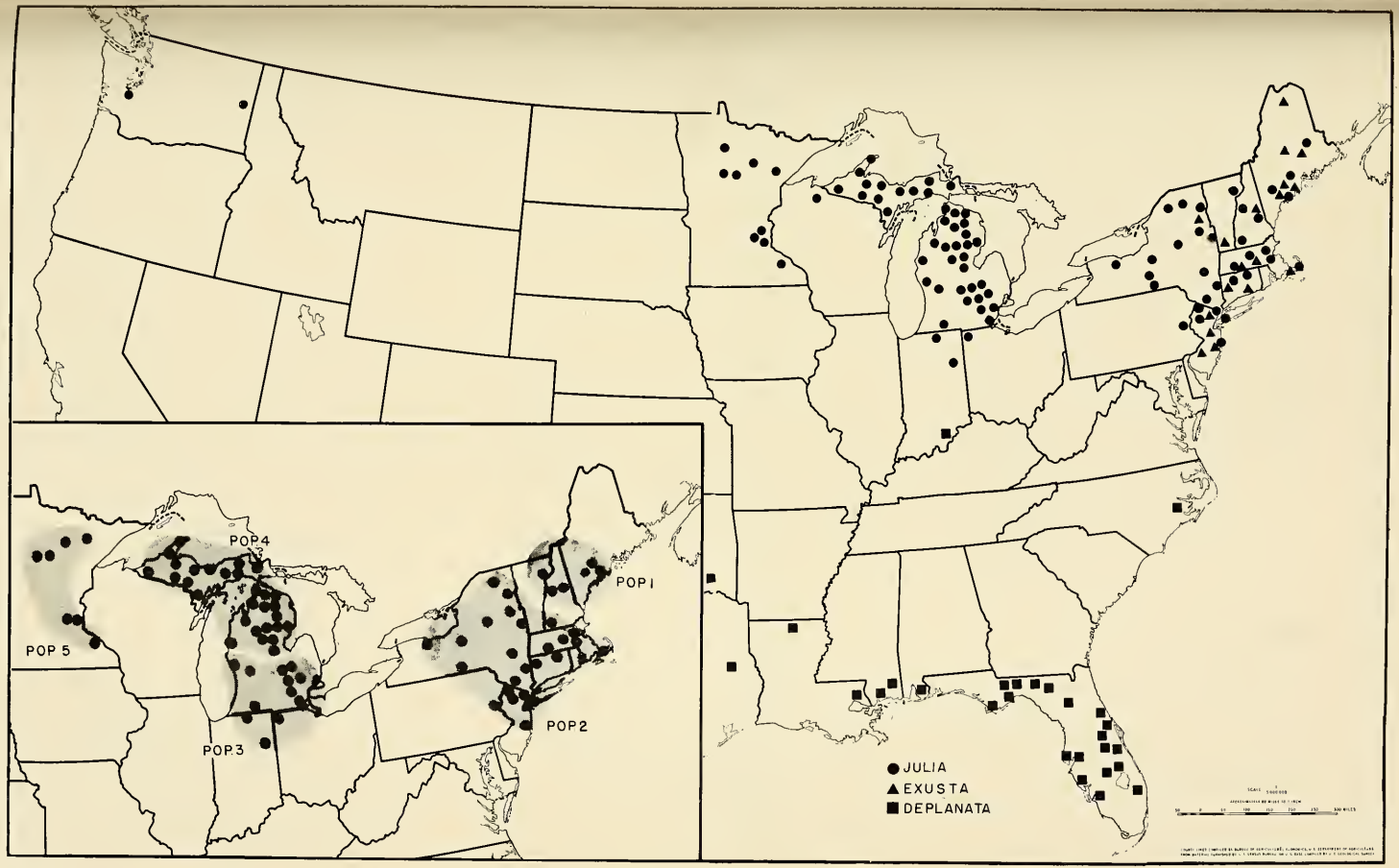

FIG. 1. Distribution of the subgenus *Ladona* in North America. Inset: distribution of male specimens of *L. julia* showing the five populations used in the study of variation.

FIGS. 2-7. Structural details of species of *Ladona*. Figs. 2, 3, penis and lateral hamulus of *L. julia*. Figs. 4, 5, same, *L. deplanata*. Figs. 6, 7, same, *L. exusta*.

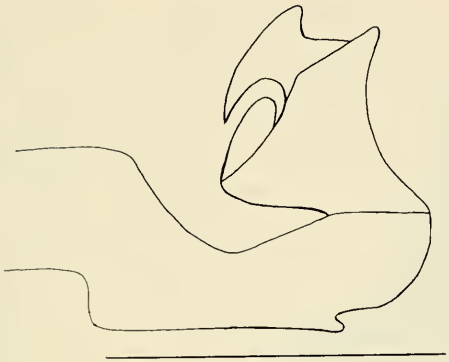

FIG. 2

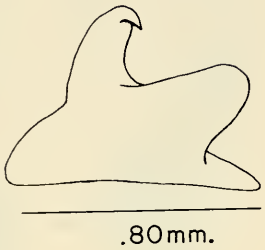

FIG. 3

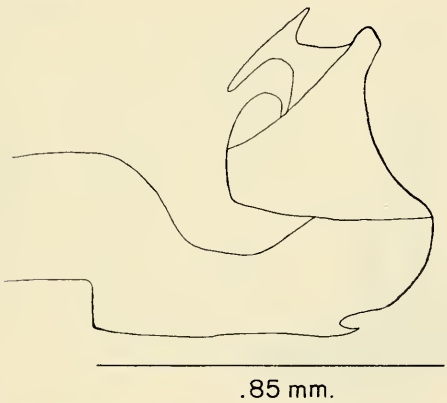

FIG. 4

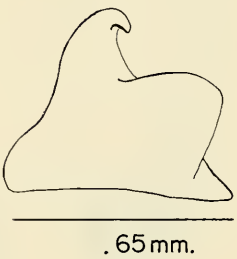

FIG. 5

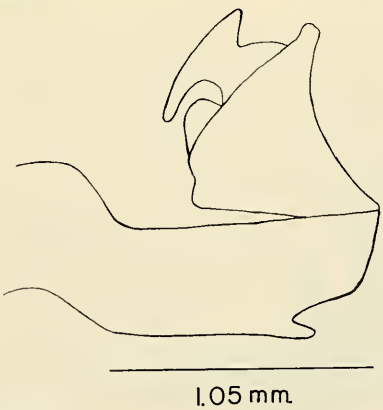

FIG. 6

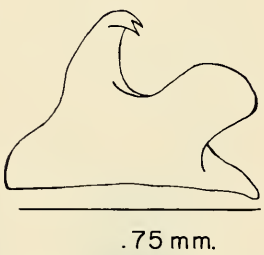

FIG. 7

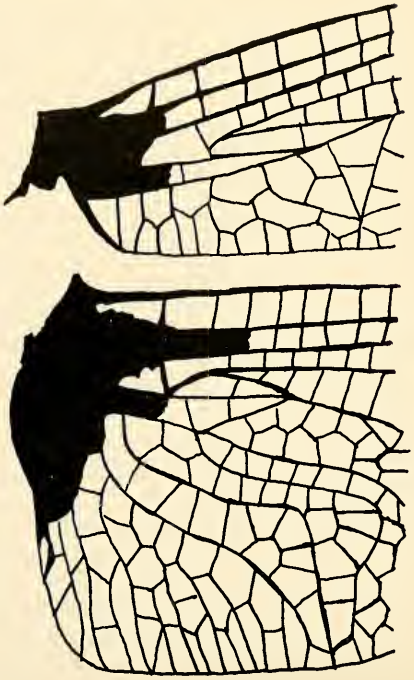

FIG. 8

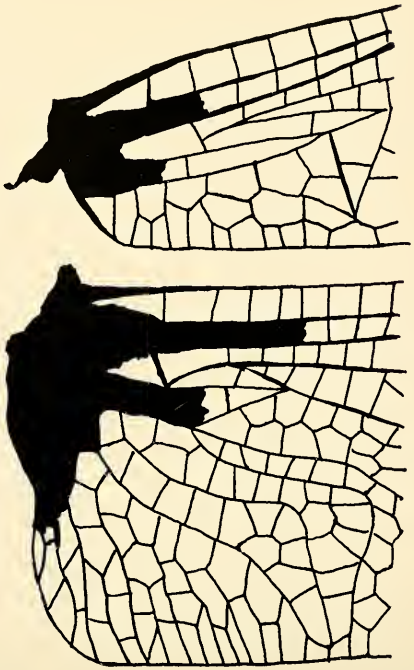

FIG. 9

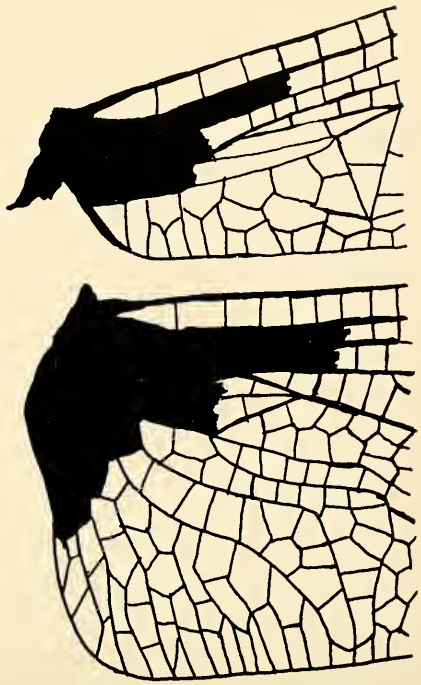

FIG. 10

FIGS. 8-10. Wing coloration in species of *Ladona;* darkened area indicates extent of interspace coloration in basal portion of wings. Fig. 8, *L. julia.* Fig. 9, *L. deplanata.* Fig. 10, *L. exusta.*

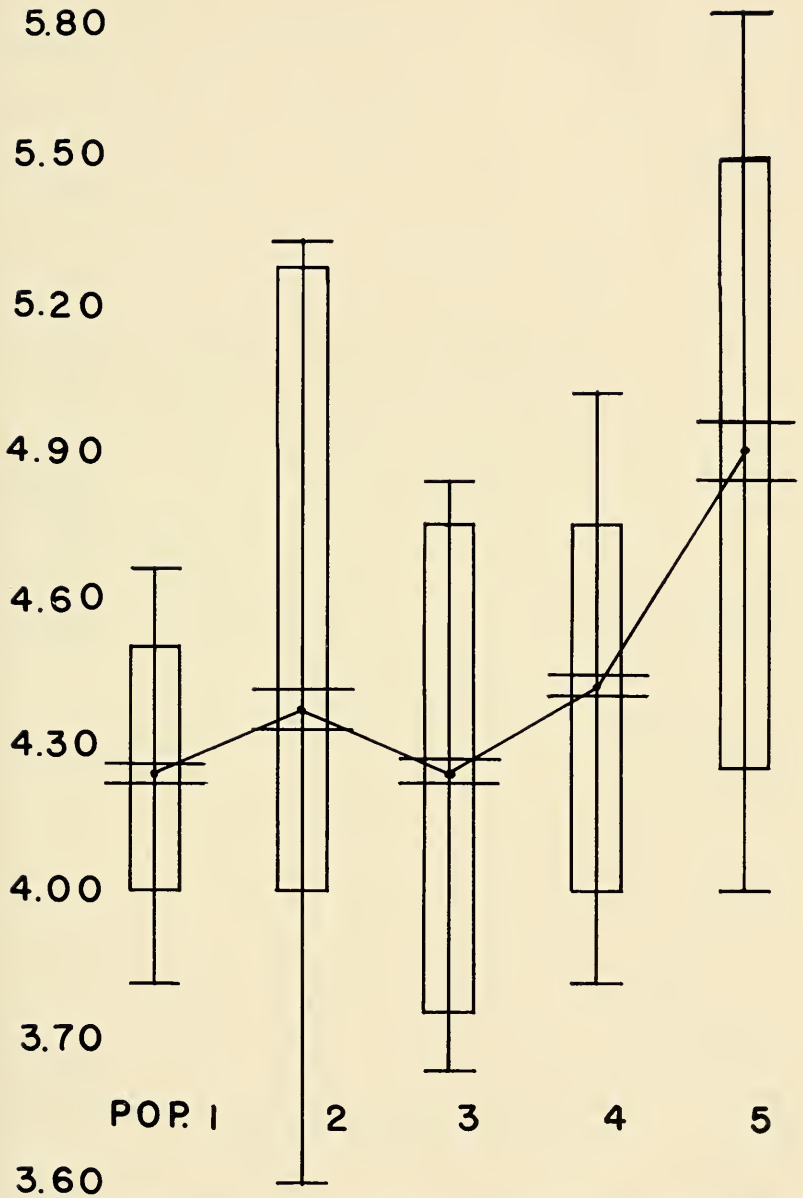

Fig. 11. Comparison of length of front tibia in five populations of males of *Libellula* (*Ladona*) *julia*. Symbols: mean (dot), standard error of mean (cross bars), three standard deviations either side of mean (vertical line), and observed range of variation (rectangle). Measurements in millimeters.

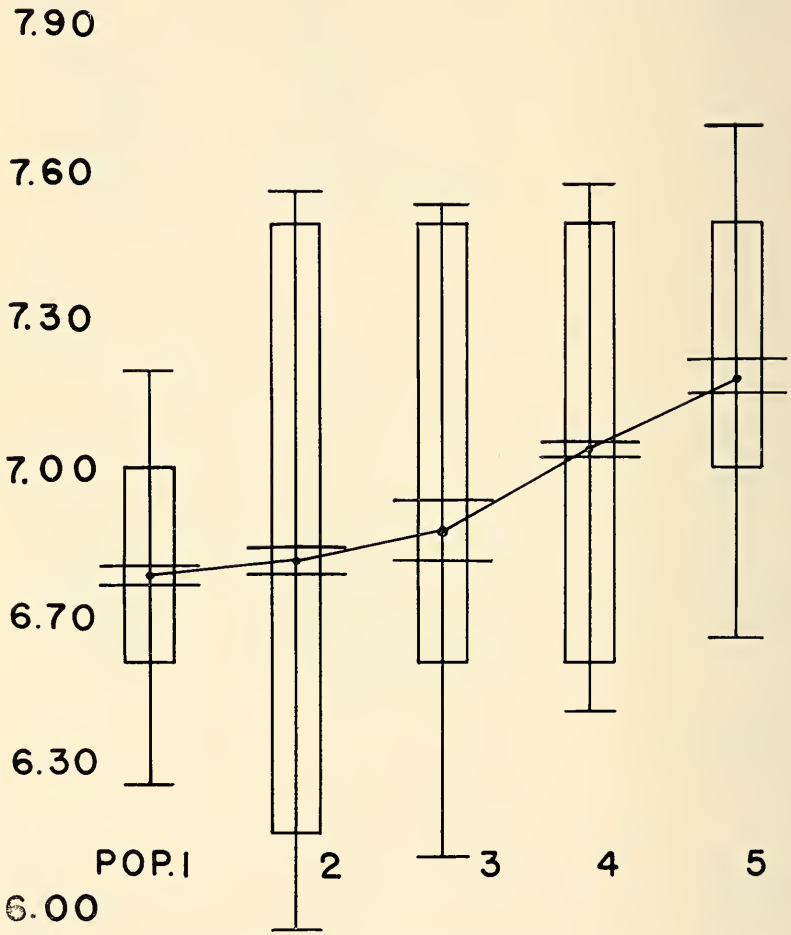

FIG. 12. Comparison of head width in five populations of males of *Libellula* (*Ladona*) *julia*. Symbols as in Fig. 11.

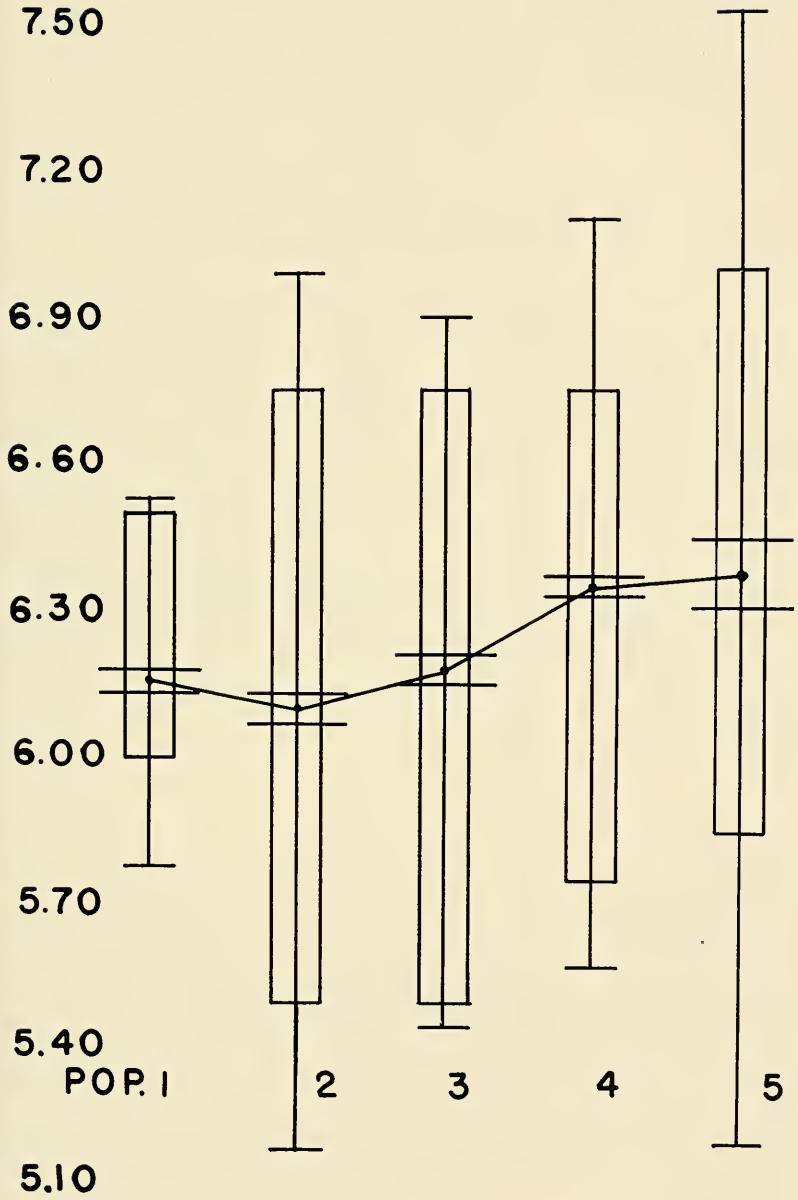

Fig. 13. Comparison of length of metathoracic femur in five populations of males of *Libellula (Ladona) julia*. Symbols as in Fig. 11.

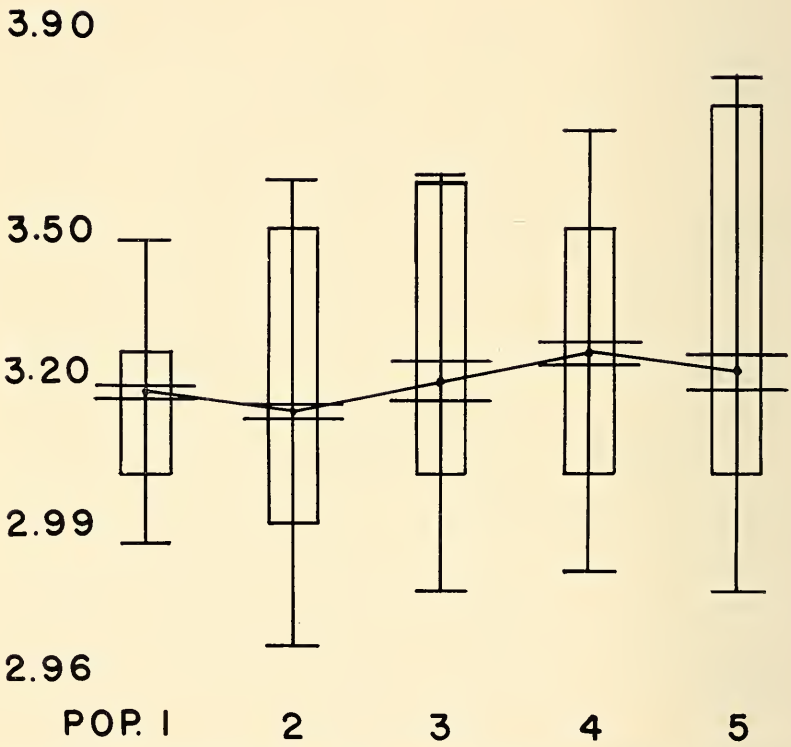

FIG. 14. Comparison of length of stigma in five populations of males of *Libellula* (*Ladona*) *julia*. Symbols as in Fig. 11.

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The genus *Ptilomera* Amyot and Serville (Gerridae: Hemiptera)*

BY

HERBERT B. HUNGERFORD and RYUICHI MATSUDA **

ABSTRACT: This paper redescribes and illustrates all types and gives a key to both males and females.

Resurrects from synonymy: *P. laelaps* Breddin, *P. oribasus* Breddin and *P. sumizome* Esaki.

Accepts *P. asbolus* Breddin and *P. argus* Breddin as synonyms of *P. dromas* Breddin. Makes *P. harpyia* Schmidt a synonym of *P. tigrina* Uhler with a reservation, *P. lachne* Schmidt as the synonym of *P. agriodes* Schmidt, *P. canace* Schmidt as synonym of *P. cingalensis* Stål.

Describes thirteen species as new: *P. assamensis* from Assam; *P. chinai, P. nunikanensis, P. kirkaldyi, P. sarawakensis, P. maai, P. gressitti* from Borneo; *P. lundbladi, P. sumatranus* from Sumatra; *P. sumbaensis* from Sumba Island; *P. timorensis* from Timor Island; *P. breddini, P. papuensis* from New Guinea.

The paper also describes *P. harpyia ceramensis* as a new subspecies from Ceram, an island in the Molluccas and *P. aëllo cheesmanae* as a new subspecies from New Guinea.

The genus *Ptilomera* Amyot and Serville

1843. Amyot et Serville, Hist. nat. Ins. Hémipt. I:413 (for Gerris laticauda Hardw. (They misspelled *G. laticaudata* Hardw.)

1853. Herrich-Schaeffer, Wanz. Insekten 9:65, Taf. 305, fig. 940. (Recorded and figured a species from Java which was not *P. laticaudata.*)

1901. Breddin, Abh. Naturf. Ges. Halle, 24:86-89 Taf. 1, figs. 10-14. (Described *P. pamphagus, P. dorceus, P. oribasus, P. laelaps* ♂.)

1903. Distant, Faun. Brit. Ind. Rhynch. 2:185.

1903. Breddin, Societas Entomologica 17:147-48. (Described four new species, *P. laelaps* ♀, *P. dromas, P. argus, P. hylactor.*)

* Contribution number 1160 from the Department of Entomology, The University of Kansas. This study was made possible with the aid of a grant from the National Science Foundation.

** The senior author takes primary responsibility for the recognition of species and for the keys and descriptions of species and the junior author for the measurements and illustrations. However, we have checked each other's work throughout.

1905. Breddin, Mit. Naturh. Mus. Hamburg, 22:132-135. (Described *P. asbolus, P. argus.*)
1906. Breddin, Societas Entomologica, 21(2):9. (Described *P. aëllo.*)
1909. Kirkaldy, Canad. Ent. 41:390. (Described *Ptilomera* (*Rheumatogonus*) subg. new.)
1925. Esaki, Philip. Jour. Sci. 26(1):59-60, Pl. 1, figs. 7-8.
1926. Schmidt, Ent. Mitteil. 15(1):63. (Described five new species, *P. agriodes, P. lachne, P. canace, P. harpyia, P. harpalos.*)
1927. Esaki, Rev. Esp. Ent. (3):251, 254, 258-261. (Described Ptilomerinae as new subf., keyed out genera, listed seventeen species of *Ptilomera.*)
1933. Lundblad, Arch. Hydrobiol. Suppl. 12, Tropische Binnengewässer 4:415-429, figs. 133-137, Taf. 13. (Proposed many synonyms.)
1934. Lundblad, Ark. Zool. 27A(14):26. (Key to genera of Ptilomerinae.)
1941. Kenaga, Univ. of Kansas Sci. Bull. 27(1):169.
1942. Kuitert, Univ. of Kansas Sci. Bull. 28(1):118.
1960. Hungerford and Matsuda, Univ. of Kansas Sci. Bull. 41(1):7. (Key to genera and subgenera of Ptilomerinae.)
1960. Matsuda, Univ. of Kansas Sci. Bull. 41(2):261-270, figs. 33, 36, 119-120, 137, 157, 166, 609-641. (Description of genus *Ptilomera.*)

Ptilomera Amyot and Serville belongs to the gerrid subfamily Ptilomerinae and can be separated from the other seven genera of this subfamily by our "Key to subfamilies, tribes, genera and subgenera of the Gerridae of the World" [Univ. of Kansas Sci. Bull. 41(1):4-5, 7-8, (1960)]. This genus is easy to recognize because all the species are rather large and stout bodied waterstriders with marked sexual dimorphism. The males have a striking fringe of hairs on the rear margin of the distal half, at least, of the middle femur. This is lacking in the female. The male genital segments are large and conspicuous while those of female are not. In this genus the males are often larger than the females which is unusual in the Gerridae. The anterior margin of the head is not bentventrad, widened posteriorly between eyes which are small, broadly rounded on the outer margin and quite broadly concave on inner margin. Antenniferous tubercles divergent anteriorly. Antennae shorter than the body. First segment longer than three following segments together; third segment longer than either second or fourth; fourth segment curved in apical third. Beak short, not extending beyond prosternum.

Apterous forms: The pronotum is subquadrangular in shape, about as wide as or a little wider than head including eyes, wider than long at middle, lateral margins broadly rounded, posterior margin nearly straight or feebly concave. Mesonotum about twice to two and a half times as long as pronotum, without either longitudinal sulcus or lateral longitudinal suture separating mesonotum from mesopleuron. Rear margin of mesonotum medially broadly

prolonged and truncate to concave at rear margin. Metanotum with a median longitudinal depressed black line. Front leg with femur straight, a little longer than tibia; tibia with a conspicuous process at inner apical angle; apical inner surface of femur and basal inner surface of tibia with some tubercles; tarsus a little shorter than tibia, first tarsal segment about twice to a little less than three times as long as second; second segment slightly thickened near apex, claws arising from near apex and with a distinct arolium. Middle leg relatively longer in male than in female; femur of male robust, with a fringe of long hairs on rear margin, except in basal one-fourth; femur in female bare and slender; tibia more or less strongly curved, with shorter fringe of hairs on inner margin in both sexes; first tarsal segment about ten times as long as second segment; second segment with small claws arising from near apex. Hind leg longer than middle leg, relatively longer in male than in female; coxa with a small spine on apical margin except in the subgenus *Proptilomera* Hungerford and Matsuda; femur a little less than twice as long as tibia; both femur and tibia without fringe of hairs; first and second tarsal segments completely fused, very short, claws arising from near apex.

Macropterous forms: Pronotum with anterior lobe well defined by transverse groove; humeri located at apical third of pronotum, posterior margin broadly rounded. Hemelytra with R + M and Cu veins basally distinct from each other, the two veins basally connected by a cross vein beyond middle of hemelytra. Vein A connected with Cu at about apical third of the wing. Hind wing with vein A distinct and connected with Cu at apical third of wing. Mesosternum has two longitudinal sutures that are not present in apterous forms.

The color and color pattern are practically generically constant. Ground color of all but two species varies from pale testaceous to ferrugineous and the black markings occupy the same relative positions in all, and are more or less covered with a silvery pubescence. Clypeus and antenniferous tubercles brown to black. Head with two pairs of black dots that may be connected into converging lines, and in dark forms also have a black line paralleling inner margin of eyes. Anterior margin of pronotum with a black spot, usually covered by silvery pile behind inner margin of each eye. These spots may or may not be joined. Anterolateral black spot is present on either side of mesonotum. Anterior and lateral margins at least of abdominal tergites dark brown to black. In side view, a brown

to black spot on each acetabulum, meso- and metapleural areas covered by a broad black longitudinal band, which may be divided into two bands either by a longitudinal stripe of slivery hairs or by a yellow stripe or by both, with silvery stripe on top of the yellow stripe. A dark band on sides of the abdomen below connexivum. Front femur with two dark longitudinal stripes, one above and one outside. Venter of thorax and abdomen from light brown to white and covered by a silvery pubescence.

Distribution: Confined to the Oriental region and some islands beyond it. In the Continental Asia it is known to occur in Hongkong, China, South India and Kashmir in the north, and eastward through Nepal, Upper Bengal and Assam, southward in Burma and Thailand and eastward in Indochina from Tonkin and Annam to Cambodia. It has been found in the following islands: Ceylon, Sumatra, Java, Borneo, Celebes, Timor, Ceram, New Guinea, Philippines and Formosa.

The most primitive living species of *Ptilomera* we believe to be *Ptilomera* (*Proptilomera*) *himalayensis* Hungerford and Matsuda from Singla Darjiling, E. Himalayas, and the species we believe to be farthest removed from the norm are *Ptilomera* (*Ptilomera*) *werneri* Hungerford and Matsuda from the Philippines and *Ptilomera* (*Ptilomera*) *timorensis* n. sp. from Timor Island.

TAXONOMIC PROBLEMS INVOLVED

When we undertook this study the problems involved in determining species in this genus seemed to us almost unsurmountable. We had plenty of warning.

Esaki (1927), who proposed the subfamily Ptilomerinae and gave a key to its genera, stated that the genus *Ptilomera* contained seventeen described species and that "This genus is taxonomically one of the most difficult groups, as all the species are more or less variable to some extent, and apparently much allied to one another." He merely listed the species.

Dr. Lundblad's (1933) study of the genus *Ptilomera* has been indispensable to us. He had examined all the types except those of *P. tigrina* Uhler, *P. dorceus* Breddin and *P. sumizome* Esaki. It was his conclusion that this is a most difficult genus, and that the females appear to be best for specific determination but are hopelessly variable as shown in his figs. 134, and 136 (see page 489). Secondly that the males appeared to him to be so variable that he did not use them in reaching his conclusion on synonymy. He re-

duced six species to synonymy and questioned two others. Thirdly, he thought that the various types might be races capable of interbreeding, and that only the study of much material and experiments in rearing might settle the questions.

How much material he studied besides the types we do not know. He recorded *P. dromas* Breddin from six collections in Java, only three of them had both sexes represented. A total of nineteen males and 35 females. Of *P. pamphagus* (his determination, not Breddin's) Lundblad recorded twelve collections from Sumatra only five of which had both sexes represented. A total of eleven males and thirteen females. With the above material it is understandable that he was perplexed.

However, we have already described two new species and in this paper are describing thirteen more. We believe the male characters are quite stable and in no species have we found the females showing the hopeless variations suggested by Lundblad (1933) in his figures 134 and 136 (which we have reproduced on page 489). In fig. 136 Lundblad figured the female type of *P. pamphagus* Breddin (A), the female type of *P. oribasus* Breddin (G), the female type of *P. laelaps* Breddin (I) all from Celebes, and six other drawings of females from Sumatra. He believed all nine drawings to be showing the variation in the female of *P. pamphagus* Breddin. When we found three males and three females of *P. laelaps* Breddin in our Kirkaldy Collection bearing the same label as the female type, we discovered that all three females were like the type of *laelaps* and the males were *not* like the type of *P. pamphagus* Breddin. We also found in the British Museum Collection a male and a female of *P. oribasus* Breddin. The female is like Breddin's type and the male is not like either *P. pamphagus* Breddin or *P. laelaps* Breddin. Undoubtedly, here are three good species from Celebes.

We believe that the females of some species show some variations in the length of the connexival spines and in the shape of the caudal lobes of the seventh abdominal segment, but in other species such variations are difficult to find. In the males there may be a little variation in the shape of the pygofer or of the paramere but such variations within a species are small.

This genus *Ptilomera* is, in our experience, almost unique. In many genera it is impossible to identify the females to species because they all look so much alike while the males possess good specific characters. In the genus *Ptilomera* it is the complexity of form of the females that trouble us.

There were other difficulties. Hardwicke (1825) described *Gerris laticaudata* from Nepal and said it was eleven lines long. If his line was 1/12 inch then it should have been more than 23 mm. long. Lundblad (1933) found the type to be around 14 mm. long. Hardwicke had before him two specimens, a macropterous form and an apterous form which he thought were females and the apterous one a nymph. They are both adult males. Yet this error is sex determination was followed by Uhler (1860) when he described *P. tigrina* from three females and thought that they were males. It was not until Breddin (1901), were the sexes correctly recognized.

The pioneer students of the genus *Ptilomera,* Breddin and Schmidt made too much of color in their descriptions. The color pattern is basically the same in all species with the black spots, covered by a silvery pile occupying the same positions in all species. The ground color varying from light to dark within a given species. Hardwicke's Fig. 4 was not correctly drawn, and Uhler did not give a figure. Breddin published figures of the apical abdominal segments of some of his species. The drawings of his female types are useful but those of the males are too small to show the real differences among the species he figured. Schmidt gave no drawings to help identify his species.

While the above authors sometimes compared the size of one species with another, we have often found more variation in size within a species than between species. The former authors sometimes gave length of the leg segments, especially the middle and hind femora, and described the fringe of hairs on the middle femur of the males. We have not found these characters to be of much use in specific determination. We began our studies by trying to measure all segments of the middle and hind legs but the tibia and tarsi are so often curved that it seemed impossible to measure accurately any of these save the femur.

The earlier authors who described species from a single sex of either male or female gave us more names than species. For example, Schmidt described a male and female from South India as different species. When we began this study we had before us the following names. Synonyms suggested by Lundblad (1933) are shown in parentheses.

1825. *P. laticaudata* (Hardwicke), Nepal, male.
1855. *P. cingalensis* Stål, Ceylon, female.
1860. *P. tigrina* Uhler, Hongkong, China, female.
1901. *P. dromas* Breddin, Java. Drawing of female in 1901, description of male and female in 1903. East and South Java.

1901. *P. dorceus* Breddin, Celebes. Described and figured female (same as *P. dromas*?).
1901. *P. pamphagus* Breddin, Celebes. Described and figured male and female.
1901. *P. oribasus* Breddin, Celebes. Described and figured female (Syn. of *P. pamphagus*).
1901. *P. laelaps* Breddin, Celebes. Described and figured male, described female in 1903 (syn. of *P. pamphagus*).
1903. *P. hylactor* Breddin, Annam. Described male and female.
1903. *P. argus* Breddin, W. Java. Described male (syn. of *P. dromas*).
1905. *P. asbolus* Breddin, W. Java. Described and figured male and female (syn. of *P. dromas*).
1906. *P. aëllo* Breddin, New Guinea. Described female.
1925. *P. sumizome Esaki,* Celebes. Described and figured male and female (syn. of *P. pamphagus*).
1926. *P. agriodes* Schmidt, South India. Described male.
1926. *P. lachne* Schmidt, South India. Described female (syn. of *P. agriodes*).
1926. *P. canace* Schmidt, Ceylon. Described male and female (syn. of *P. cingalensis*).
1926. *P. harpyia* Schmidt, Cambodia. Described female.
1926. *P. harpalos* Schmidt, W. Sumatra. Described male and female.
1931. *P. shirakii* Esaki, Formosa (nomen nudum).
1958. *P. werneri* Hungerford and Matsuda, Philippines. Described and figured male and female.
1958. *P. himalayensis* Hungerford and Matsuda, Himalaya.

Thus there were twenty one names, one of which is a nomen nudum, and eight possible synonyms as suggested by Dr. Lundblad. Moreover, only ten species were known from both sexes. Three species from males only and seven species from females only.

From our preliminary studies of this genus we found the male characters quite stable and in no species did the females show the hopeless variation suggested by Lundblad (1933) in his figures 134 and 136. It seemed imperative that we re-examine the types of all species of *Ptilomera.* This we were permitted to do by the kindness of the following: Dr. R. Sailer of the U. S. National Museum in Washington D. C., Dr. W. E. China and Mr. R. J. Izzard of the British Museum in London, Dr. T. Jaczewski of the Polish Academy of Sciences in Warsaw, Dr. H. Sachtleben of the Deutsches Entomologisches Institut in Berlin and Mr. T. Hidaka of the Kyushu University in Fukuoka, Japan. Our task has been to redescribe and illustrate all types, find females to match three male types and males to match seven female types and prove or disprove all synonymys. This we have been able to do for all but two. We need males of *P. tigrina* Uhler from Hongkong, China and of *P. dorceus* Breddin from Celebes. Although Lundblad saw the male type of *P. pamphagus* from Celebes, he illustrated instead (his fig. 137, 1933) a

male specimen from Sumatra which is not *P. pamphagus*. Probably it is the male of the same species as the female he figured as B on his fig. 136. They came from the same place.

We have found that the males provide a number of useful characters for the separation of species. The shape of the pygofer, the suranal plate and the paramere are remarkably constant for a species, so is the position of the metacoxae. 21 units in the measurements of relative lengths of various structures equal to 1 mm. For the terminologies used in the description refer to pl. I.

PLATE I

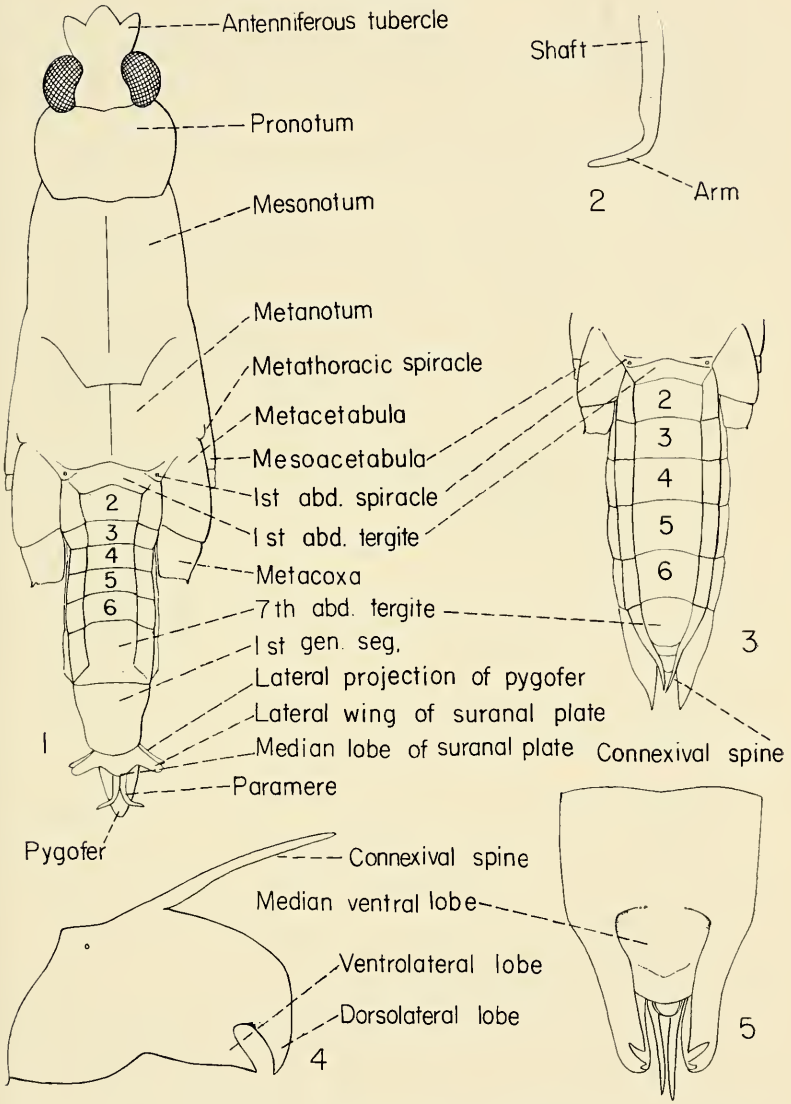

FIG. 1. Male of *Ptilomera* (*Ptilomera*) *äello cheesmanae* Hungerford and Matsuda.

FIG. 2. Left paramere of *Ptilomera* (*Ptilomera*) *sumbaensis* Hungerford and Matsuda.

FIG. 3. Female abdomen of *Ptilomera* (*Ptilomera*) *harpalos* Schmidt.

FIG. 4. Lateral view of female seventh abdominal segment of *Ptilomera* (*Ptilomera*) *sumbaensis* Hungerford and Matsuda.

FIG. 5. Ventral view of female seventh abdominal segment of *Ptilomera* (*Ptilomera*) *sumbaensis* Hungerford and Matsuda.

Key to the Species of *Ptilomera*

KEY TO MALES

1. Rear margin of metacoxa without thorn-like projection.
P. (*Proptilomera*) *himalayensis* Hungerford and Matsuda (Himalaya), p. 414

Rear margin of metacoxa with thorn-like projection.
P. (*Ptilomera*) spp. 2

2.(1) Males. Middle femur with a fringe of hairs on its outer third at least 3

Females. Middle femur without such a fringe 28

3.(2) Paramere bifurcate.
P. werneri Hungerford and Matsuda (Philippines), p. 511

Paramere not bifurcate 4

4.(3) Dorsolateral projections of pygofer, as seen from above, extending half their length beyond lateral wings of suranal plate.
P. agrioides Schmidt (India), p. 431

Dorsolateral projections of pygofer, as seen from above, much shorter, never extending half their length beyond lateral wings of suranal plate, often even shorter than lateral wings of suranal plate 5

5.(4) Apical margin of pygofer broad, nearly truncate or depressed at middle. Lateral margins of pygofer parallel or nearly parallel sided beyond lateral projections 6

Apex of pygofer pointed, narrowly rounded or blunt. Lateral margins of pygofer beyond its dorsolateral projections more or less strongly convergent 8

6.(5) Lateral wings of suranal plate well developed, reaching or extending beyond median lobe of suranal plate ... *P. chinai* n. sp. (Borneo), p. 438

Lateral wings of suranal plate never reaching apex of median lobe caudally 7

7.(6) Median lobe of suranal plate broad. Seen in side view venter of pygofer medially transversely constricted. Tip of pygofer not notched. Arm of paramere broadly spatulate at tip.
P. cingalensis Stål. (Ceylon), p. 427

Median lobe of suranal plate not broad. Seen in side view, venter of pygofer not medially transversly constricted. Tip of pygofer notched. Arm of paramere not spatulate at tip.
P. timorensis n. sp. (Timor Isl.), p. 436

8.(5) Median lobe of suranal plate large, clearly surpassing lateral wings caudally 9

Median lobe of suranal plate not large, slightly surpassing or not surpassing lateral wings caudally 11

9.(8) Paramere of usual shape as shown on pls. III and IV 10

Paramere long and slender as shown on plate V.
P. sarawakensis n. sp. (Borneo), p. 424

10.(9) Arm of paramere as seen from the rear as shown on pl. III, figs. 3, 6.
P. laticaudata (Hardwicke) (Nepal), p. 416

Arm of paramere as seen from the rear. pl. IV. fig. 6.
P. assamensis n. sp. (Assam), p. 421

11.(8) As seen from below pygofer conspicuously broad beyond its middle 12

As seen from below pygofer not conspicuously broad beyond its middle 14

12.(11) Caudal half of that section of pygofer beyond its lateral projections parallel sided as seen from below. As seen laterally this distal portion is turned dorsally to a truncate tip as shown on pl. X, figs. 6, 7 .....
P. nunikanensis n. sp. (Indonesian Borneo), p. 441

Pygofer unusally broad beyond its dorsolateral projections, with sides converging to a dorsally directed point as shown on pl. XI, fig. 6 and pl. XII, fig. 2.....13

13.(12) Lateral wings of suranal plate longer than broad, plainly surpassing median lobe, their rear margins longer than width of their tips. The paramere shape as shown on pl. XI, figs. 4, 7.
P. kirkaldyi n. sp. (Borneo), p. 444

Lateral wings of suranal plate short, broad, only slightly surpassing median lobe, their rear margin not longer than the width of their tips. The paramere shape as shown on pl. XII, figs. 2, 3.
P. gressitti n. sp. (Borneo), p. 446

14.(11) Venter of pygofer with basal two-thirds narrow, resembling a broad keel. Sides above the keel concave to a position beyond the lateral projections of the pygofer. Venter of first genital segment with a well developed keel. (Pl. XIII, fig. 3.)
P. hylactor Breddin (Annam), p. 448

Venter of genital segments not as above.....15

15.(14) Lateral wings of suranal plate with front and rear margins nearly parallel.....16

Lateral wings of suranal plate with front and rear margins not parallel.....19

16.(15) Lateral wing of suranal plate long, surpassing median lobe.....17

Lateral wing of suranal plate not surpassing median lobe.....18

17.(16) Median lobe of suranal plate short, but broader than width of lateral wing. Arm of paramere as seen in rear view with a ventral bulge or keel. (Pl. XIV, fig. 4.)
P. breddini n. sp. (New Guinea), p. 451

Median lobe of suranal plate longer than in above, but not wider than width of lateral wing. Arm of paramere as seen in rear view without the ventral bulge or keel. (Pl. XV, fig. 4.)
P. papuensus n. sp. (Papua), p. 454

18.(16) Lateral wing of suranal plate short, its rear margin a little longer than the width of its tip. (Pl. XXVIII, fig. 2.)
P. oribasus Breddin (Celebes), p. 497

Lateral wing of suranal plate longer, its rear margin nearly twice as long as the width of its tip. (Pl. XVI, fig. 7.)
*P. aëllo cheesmanae** n. subsp. (New Guinea), p. 459

19.(15) Median lobe of suranal plate plainly surpassing lateral wings....20

Median lobe of suranal plate not plainly surpassing lateral wings, 21

20.(19) Exposed shaft of paramere broad and short. (Pl. XXVII, fig. 5.)
P. harpalos Schmidt (Sumatra), p. 493

Exposed shaft of paramere more slender. (Pl. XXIV, fig. 5.)
P. laelaps Breddin (Celebes), p. 488

21.(19) Lateral wings of suranal plate plainly surpassing median lobe....22

Lateral wings of suranal plate not plainly surpassing median lobe, 23

22.(21) Exposed shaft of paramere longer than its arm. Hind coxa reaching rear margin of fifth abdominal tergite. (Pl. XX, fig. 3.)
P. sumbaensis n. sp. (Sumba Isl.), p. 474

Exposed shaft of paramere not as long as its arm. Hind coxa only reaching rear margin of fourth abdominal tergite. (Pl. XXI, fig. 3.)
P. maai n. sp. (Borneo), p. 476

23.(21) Lateral projection of pygofer indorsal view extending one-fifth its length beyond the lateral wing of suranal plate. Paramere long, slender, its shaft and arm in a continuous curve. (Pl. XXII, fig. 3.)
P. pamphagus Breddin (Celebes), p. 478

Lateral projection of pygofer shorter. Paramere shaft and arm not slender.....24

* Male of *P. aëllo aëllo* Breddin is unknown to us.

24.(23) Distal half of that portion of pygofer beyond its lateral projections unusually slender, its caudal tip pointed.....25

Distal half of that portion of pygofer beyond lateral projections of usual shape and its caudal tip blunt.....26

25.(24) Ground color of body and legs dark chocolate brown, nearly black, so dark that the black markings common to all species are all but obscured, even the longitudinal black bands of the front femur. Distal half of dorsum of first genital segment abnormally elevated. (Pl. XXIII, fig. 4.) Rear view of the arm of the paramere shows it straight, nearly parallel sided, and its tip rounded. (Pl. XXIII, fig. 3.) In dorsal view arm of paramere obscured by many long hairs.
P. sumizome Esaki (S. O. Celebes), p. 481

Ground color of body and legs reddish orange with the characteristic black markings of the genus. Distal half of dorsum of first genital segment not abnormally elevated. Rear view of arm of paramere shows it curved obliquely dorsad. Its sides not parallel. (Pl. XII, figs. 5, 6.).....*P. harpyia* Schmidt* (Cambodia), p. 466

26.(24) Lateral wings of suranal plate slightly surpassing median lobe.
P. dromas Breddin (syn. *P. argus* Breddin) (syn. *P. asbolus* Breddin) (Java), p. 503

Lateral wings of suranal plate not surpassing median lobe.....27

27. Arm of paramere as seen from the rear with a ventral keel as shown on pl. XXIV, figs. 4, 5. Exposed shaft of paramere longer than the curved arm.....*P. sumatranus* n. s. (Sumatra), p. 485

Arm of paramere as seen from the rear without a ventral keel. Exposed shaft of paramere not longer than the straight arm.
P. lundbladi n. sp. (Sumatra), p. 488

KEY TO FEMALES

28.(2) Rear margin of metacoxa without thorn-like projection. Without connexival spines.
P. (*Proptilomera*) *himalayensis* Hungerford and Matsuda (Himalaya), p. 414

Rear margin of metacoxa with thorn-like projection. With connexival spines.....*P.* (*Ptilomera*) species 29

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In side view the ventrolateral lobe of seventh abdominal segment longer than the venter of seventh abdominal segment before it. In ventral view the ventrolateral lobes of types of both *P. tigrina* and *P. harpyia* are truncate at tips. However, the latter species seems to vary as shown on pl. XVIII, figs. 5 to 9.....56

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The dorsolateral lobe broad at base as shown on pl. XVIII, figs. 2, 5, 7, 8, 9. Ventrolateral lobes not as above.

P. harpyia Schmidt* (Cambodia), p. 466

Besides those we have keyed out above we have a female from "Oek Simakock, N. Habinsoram, Sumatra July 3, 1931 V. D. Meer Mohr" that looks like Lundblad's E in his fig. 136, and a male from the same place but on Aug. 4, 1931. They are none of the species we have keyed out. Lundblad's specimen came from Belige, W. Sumatra.

Since males are quite constant in their combination of characters and can be satisfactorily keyed out we believe that with careful study there will be recognized more species rather than fewer species in this difficult genus. In some species the females vary so slightly that they are readily keyed out but there are others that appear to be so variable that they make trouble when we try to place them in a key. We have done our best to enable one to identify the females encountered, but we are conscious of its shortcomings and have provided illustrations of all species.

Ptilomera (*Proptilomera*) *himalayensis* Hungerford and Matsuda

Plate II

1958. *Ptilomera* (*Proptilomera*) *himalayensis* Hungerford and Matsuda, Bull. Brooklyn Ent. Soc. 53(5):117-123, 2 Pls. (Described new subgenus and species from Singla Darjiling. E. Himalayas.)

1960. *Ptilomera* (*Proptilomera*) *himalayensis* Hungerford and Matsuda, Univ. Kansas Sci. Bull. 41(1):7, 17 fig. 33. (subgenus *Proptilomera.*)

1960. *Ptilomera* (*Proptilomera*) *himalayensis,* Matsuda, Univ. of Kansas Science Bull. 41(2):267, 537 figures 539, 609, 614, 615, 620, 624.

Redescription of subgenus *Proptilomera*

More primitive group of the genus *Ptilomera,* represented by *P. himalayensis.* It lacks the metacoxal thorn-like projection that is present in all other species. The seventh abdominal and genital segments of both sexes are simple and more primitive than in other species of the genus. The seventh abdominal tergite short in both sexes. First genital of male short, broad without a ventral keel. The pygofer also short and broad, lacking a distinct dorsolateral projection. Paramere simple, not divided into a shaft and arm.

* A small male and female from Ceram Island, one of the Molluccas, ran out here but appear to be a subspecies evolved on this island. See Pl. XIX. *P. harpyia ceramensis* n. subsp. (Ceram), p. 470.

Whether *P. tigrina* and *P. harpyia* are one variable species or distinct species must await the discovery of males of *P. tigrina* accompanied by females.

PLATE II

Ptilomera (*Proptilomera*) *himalayensis* Hungerford and Matsuda

FIG. 1. Apterous female from Kurseong, Himalayas (Brit. Mus.). Note the absence of metacoxal thorn-like spine and connexival spine.

FIG. 2. Apterous male from Kurseong, Himalayas (British Mus.). Note both the absence of metacoxal thorn-like spine and the very large first genital segment that almost covers the second genital segment.

FIG. 3. Suranal plate of the male paratype, showing the elongate median lobe and the curious hook-like wings of suranal plate.

FIG. 4. Macropterous male holotype.

FIG. 5. Macropterous female allotype. Dorsal view of caudal abdominal segments. Note the large seventh abdominal tergite and the ends of the median lobe of the seventh ventrite on either side of the anal segment.

FIG. 6. Macropterous female allotype. Side view of caudal abdominal segments to show the curious shape of the median caudal lobe of the seventh abdominal ventrite.

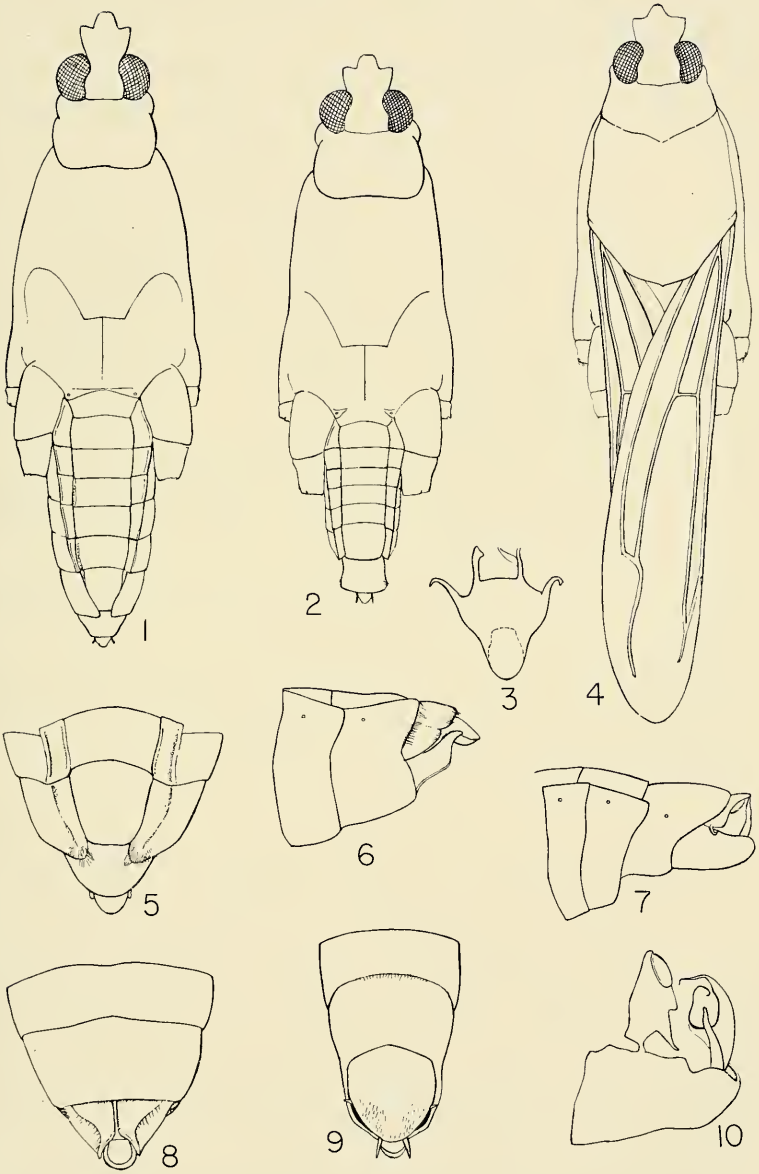
FIG. 7. Male holotype. Side view of caudal abdominal segments showing the curious lateral wing of suranal plate which is nearly covered by large first genital segment, the short pygofer and the erect paramere.

FIG. 8. Female allotype. Ventral view of the caudal abdominal segments. Note the median longitudinal keel on the distal lobe of the seventh abdominal ventrite and the caudolateral projections, the tips of which are shown in figure 5 above.

FIG. 9. Holotype male, ventral view of genital segments.

FIG. 10. Paratype male, side view of pygofer, suranal plate, paramere and endosoma.

PLATE II



Suranal plate not typically three lobed and entirely exposed, but hidden beneath dorsum of first genital, median lobe comprising most of the suranal plate, the lateral wings slender, not lobe-like, with only their curved tips exposed beyond the caudolateral margin of the first genital segment.

Female without connexival spines. Seventh segment without distinct dorsolateral or ventrolateral lobes on its rear margin which is straight. Median caudal lobe of seventh sternite with a distinct median longitudinal ridge, its lateral margins converging then turned obliquely outward to produce on either side a flat caudolateral projection, the ends of which are visible in dorsal view.

Description of *Ptilomera* (*Proptilomera*) *himalayensis*

Size: Male holotype (macropterous): Length including wings 14.4 mm.; width of head 1.64 mm.; width of anterior lobe of pronotum 2.1 mm.; width across humeri 2.8 mm.; greatest width of body across mesoacetabula 3.48 mm.

Female allotype (macropterous): Length including wings 14.44 mm.; width of head 1.68 mm.; width of anterior lobe of pronotum 1.93 mm.; width across humeri 2.81 mm.; greatest width of body across mesoacetabula 3.90 mm.

Male (apterous): Length 10.48 mm.; width of head 1.7 mm.; width of pronotum 2.00 mm.; length of mesonotum 2.80 mm.; greatest width of body across mesoacetabula 3.48 mm.

Female (apterous): Length 12.48 mm.; width of head 1.83 mm.; width of pronotum 2.05 mm.; length of mesonotum 2.95 mm.; greatest width of body across mesoacetabula 4.05 mm. We have seen a macropterous male that is 15.5 mm. long including wings, and an apterous male only 10.1 mm. long.

Color: Apterous forms have the color and pattern typical for the genus except that the black band on the side of the mesothorax is narrower, undulate, and not divided. Mesothorax with a lateral black band, broader in front, and reaching back onto metacetabula; mesoacetabula with a black spot. Venter pale testaceous, covered with short silvery pile. Abdominal tergites of deälated male with black bands covered with silvery pile across bases of first four segments. Antennae brown. Legs testacenes to reddish brown; anterior femora with two longitudinal reddish brown bands; middle and hind femora pale testaceous at tips.

The macropterous forms: reddish brown to testaceous above, wings brown. Head with two or more indefinite embrowned spots. Prothorax with a black spot on anterior median margin, a transverse

band on anterior margin of posterior lobe broken in the middle by a low testaceous carina; sides of anterior lobe with a longitudinal dark band not reaching to eyes and a large spot in proacetabula.

Structural Characteristics: Relative length of antennal segments of male holotype. 1st:2nd:3rd:4th::125:30:44:25, of the female allotype, 1st:2nd:3rd:4th::115:27:40:?. The last segment of the holotype somewhat curved and flattened.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male (holotype)	7.43 mm.	6.19 mm.	2.85 mm.	1.42 mm.
Male (apterous)	6.81 mm.	5.71 mm.	2.76 mm.	1.29 mm.
Female (allotype)	6.29 mm.	5.24 mm.	2.38 mm.	1.24 mm.
Female (apterous)	6.67 mm.	5.71 mm.	2.52 mm.	1.29 mm.

Middle leg	Femur	Hind leg	Femur
Male (holotype)	19.50 mm.	Male (holotype)	25.37 mm.
Male (apterous)	19.05 mm.	Male (apterous)	22.60 mm.
Female (allotype)	16.90 mm.	Female (allotype)	19.60 mm.
Female (apterous)	17.14 mm.	Female (apterous)	20.48 mm.

In the hind leg of the deälated Male paratype which is larger than the holotype, the femur is 28.09 mm. long. The front femur of the male is rather stout and has a characteristic shape. The front femur of female is normal in shape and provided with a small black protuberence ventrally near distal end. This protuberence is larger in the male. Tibia of front leg also has three small protuberences on its inner base; these protuberences are smaller in female than in male. Male middle femur with densely ciliated ventral margin confined to distal two-fifths; basal three-fifths bare; metacoxal spine represented by a blunt black protuberance. Length of pregenital segments:genital segments::60:30. Seventh abdominal tergite of male short, not longer than the fifth and sixth together. Male genital segments: first genital segment broad and short; without a ventral keel. Suranal plate small. In normal position almost entirely hidden, its median lobe obscured by the dorsum of first genital, its lateral lobes slender and hidden except for their tips. (See Plate II fig. 3.) Pygofer simple, short and broad, without dorsolateral projections of all other species. Paramere as shown on Plate II fig. 10.

Female. Length of thorax:abdomen::102:99. Seventh abdominal segment is also simple and quite primitive. Seventh abdominal tergite short, only slightly longer than sixth, without connexival spines. In dorsal view the black projection one on each side near the caudal apex of the insect are the tips of prolongations of the seventh sternite, which in other species of *Ptilomera* is a single flap

that is nearly truncate across its end. In side view there are only slight indications of lateral lobes so striking in other species of this genus.

Types: The macropterous male holotype, macropterous female allotype and a deälated male paratype bear the label "Singla Darjiling, E. Himalayas June 13. 1500 ft. Ld. Carmechael" in the Francis Huntington Snow Coll., The University of Kansas.

Distribution: In addition to the types we have seen the following:

"Mungphu" 2 macropterous males (British Mus.); "Ind Mus. Kurseong Alt. 3200 ft. E. Himalayas. 2, 6. III-10. F. Gravely." apterous male and female. (British Mus.); "N. India" 1 deälated male. (British Mus.) "Sikkim, Gopaldhara, Rungbong Vall. H. Stevens." two apterous male, one apterous female. (British Mus.). These British Museum specimens bear a manuscript name, "*Ptilomera primitiva* Lundblad" and were seen there by the junior author (1960) who recognized them as our *Ptilomera* (*Proptilomera*) *himalayensis* Hungerford and Matsuda and were borrowed so that we could describe the apterous forms. It is evident that Dr. Lundblad before 1933 recognized that this is a primitive species and his name would have been more meaningful than our own.

Ptilomera (*Ptilomera*) *laticaudata* (Hardwicke)

Plate III

1825. *Gerris laticaudata* Hardwicke, Trans. Linn. Soc. 14:134 Tab. VI figs. 1-4. (Described from "Nepaul". His figure 2 is an adult male not a nymph and figure 4 incorrectly drawn. Types in British Museum.)

1843. *Ptilomera laticauda* (Hardwicke), Amyot et Serville Hem. 413-414. P. VIII fig. 3. (Described the genus but misspelled *laticaudata* and added Java in error.)

1853. *Ptilomera laticauda,* Herrich-Schäffer, Wans. Ins. 9:65 fig. 940. (Unknown to him but copied from Amyot and Serville).

1866. *Ptilomera laticauda,* Mayr, Novara-Exped. Zool. Theil Bd. 2(1):177. (Followed Amyot and Serville in making *P. cingalensis* Stål a synonym and questioned *P. tigrina* Uhler).

1900. *Ptilomera laticaudata,* Horváth, Semon Zoologische Forschungsreisen in Australien und dem Malayischen Archipelagos, Denkschriften VIII 639, (Reports from Buitenzorg, Java. Surely not above species).

1904. *Ptilomera laticaudata,* Distant, Fau. Brit. Ind. Rhynch. 2:185. (Only first three references above apply to this species. He was in error in making synonyms of *P. cingalensis* Stål and *P. tigrina* Uhler. His figure 133 is not of *P. laticaudata* (Hardw.) and the drawing he labeled female is a male which looks like *P. agriodes* Schmidt).

1927. *Ptilomera laticaudata,* Esaki, Eos, Rev. Esp. Ent. 3(3):258 (questions all distributional records except Nepal).

1933. *Ptilomera laticaudata,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 373, 418, 422-423. fig. 133. (Saw and redescribed the type and gave drawings of male genitalia).

1958. *Ptilomera laticaudata,* Hungerford and Matsuda, Bull. Brooklyn Ent. Soc. 53(5):117-118, Pl. I, Pl. II G-H. (Described and figured female and thought this to be this species.)

1960. *Ptilomera laticaudata,* Matsuda, Univ. of Kansas Sci. Bull. 41(2):267, 269, 537, 541, (Fig. 619 on p. 537 not *laticaudata*). The following references are misdeterminations:

1892. *Ptilomera laticaudata,* Kirby, Linnean Soc. Jour. Zool. 24:124. (Not *P. laticaudata* (Hardw.) but *P. cingalensis* Stål.)

1899. *Ptilomera laticaudata,* Kirkaldy, Ann. Soc. Ent. Belg. 43:508. (Recorded a female from "S. Celebes, Samanga. (Fruhstorfer Nov. '95.)" In Kirkaldy Collection we find 3♂♂ and 2♀♀ from this place. They are *P. laelaps* Breddin).

1901. *Ptilomera laticaudata,* Breddin, Abh. Naturf. Ges. Halle Bd. 24:20. (Quoted Kirkaldy as 1899.)

1918. *Ptilomera laticaudata,* Paiva, Records of Indian Museum 14:24 (Probably *P. agriodes* Schmidt.)

1919. *Ptilomera laticaudata,* Paiva, Records of Indian Museum 16, Pt V, No. 23, 365.

For more than one hundred years this species from Nepal remained indistinguishable in the literature. Then in 1933 Dr. Lundblad saw the types, an apterous male and a macropterous male with broken wings, in the British Museum. He redescribed the types and gave drawings of the male genitalia. In 1958 we described a lone female from Darjiling, just east of Nepal that we thought might be the female of *P. laticaudata* (Hardw.) but stated that the determination could not be certain until both sexes were taken together from one place. Now we have found, in the Collection of the British Museum, one male and two females from Sikkim. The females are like our neallotype of *P. laticaudata* from Singla, Darjiling, East Himalayas and the male is like the two male types of *P. laticaudata* in the British Museum. Therefore, we now know both sexes of *P. laticaudata* (Hardwicke). A closely related species from Assam is described after this species.

Size: Although Hardwicke gave the length of this species as eleven lines, Lundblad (1933) said the type male is relatively small and around 14 mm. long. Since the genitalia in both male types have now been removed and the identification confirmed, we accept the length given by Lundblad. Mr. Izzard of the British Museum has obligingly sent us the following measurements: Width across the head including eyes 2.73 mm.; width of pronotum 2.73 mm.; length of mesonotum (apterous form) 3.73 mm. Our neallotype was also described without some of the measurements we are giving in this paper. Here we give them for the Female. Length 14.19 mm.; width of head 1.95 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.95 mm.

Ptilomera (*Ptilomera*) *laticaudata* (Hardwicke)

FIG. 1. Male from Sikkim. Compared with type of *Ptilomera laticaudata*.

FIG. 2. Male. Ventral view of genital segments of the above specimen from Sikkim.

FIG. 3. Rear view of right arm of paramere of *P.* (*Ptilomera*) *laticaudata* (Hardwicke) from Sikkim.

FIG. 4. Female neallotype of *Ptilomera laticaudata* by Hungerford and Matsuda.

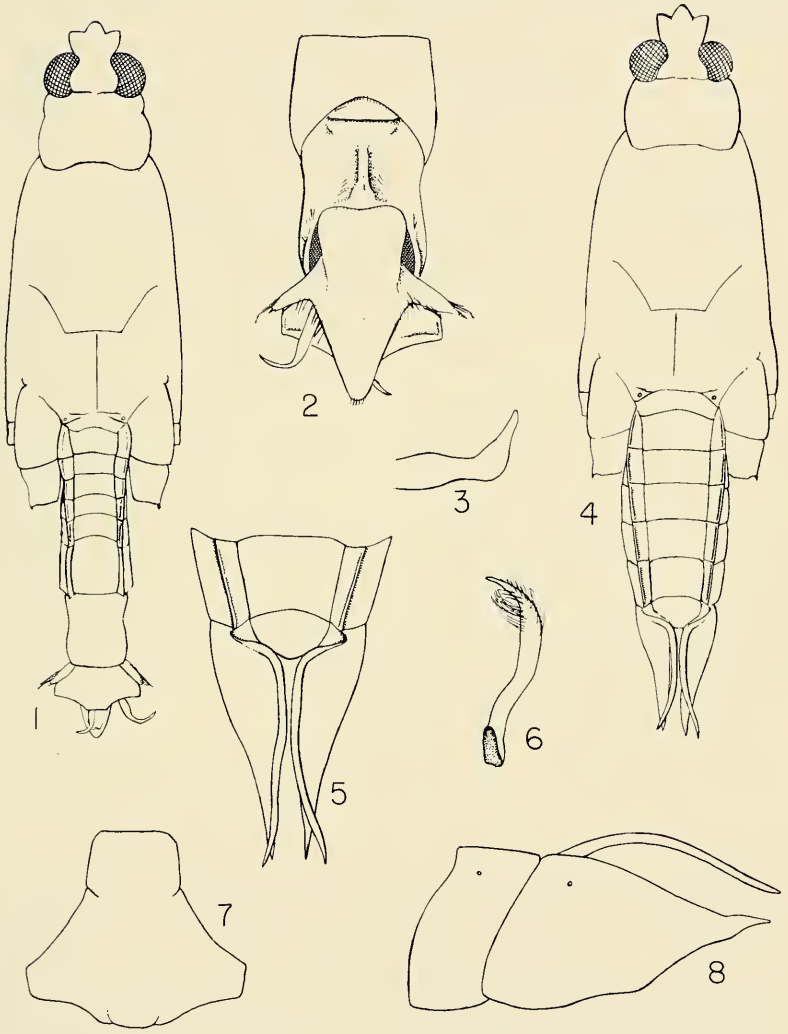
FIG. 5. Female neallotype, dorsal view of sixth and seventh abdominal segments.

FIG. 6. Male. Paramere of a type drawn from a slide mount by Matsuda at the British Museum.

FIG. 7. Male type. Suranal plate drawn from a slide mount by Matsuda.

FIG. 8. Female neallotype. Side view of sixth and seventh abdominal segments.

PLATE III



Color: Typical for the genus. However, all three females known to us have four black dots on the vertex.

Structural characteristics: The male types now lack antennae. However, if Hardwicke's fig. 3 is correctly drawn then the relative length of antennal segments of the Male are 1st:2nd:3rd:4th::34:10:12:7+. Those of our neallotype 125:25:37:?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male type *	7.33 mm.	5.20 mm.	3.66 mm.	1.66 mm.
Female neallotype (apterous)	6.57 mm.	5.62 mm.	3.00 mm.	
Female Sikkim, (apterous)	6.76 mm.	5.81 mm.	3.43 mm.	1.52 mm.

Middle leg	Femur	Hind leg	Femur
Male type *	25.00 mm.	Male type *	30.00 mm.
(apterous)	17.14 mm.	Female neallotype (apterous)	20.00 mm.
Female Sikkim, (apterous)	18.19 mm.	Female Sikkim, (apterous)	20.38 mm.

Length of pregenital abdominal segments: Genital segments::73:57 (from Sikkim). Male genital segments: Suranal plate with median lobe very broad but short, not as long as the distal width of a lateral wing, yet surpassing the latter caudally (unlike the drawing in Hardwicke's Fig. 4). Front and rear margins of lateral wings not parallel. Pygofer relatively short, its tip bluntly pointed, dorsolateral projections stout, short and bluntly rounded at tip. Paramere in dorsal view slightly sigmoid, the union of shaft and arm indistinct. In rear view the dista half of arm as shown in Lundblad's figure 133 and as fig. 3 of Plate III.

Female neallotype. Length of thorax:Abdomen::120:136. Seventh abdominal tergite with rear margin not appearing broadly rounded. Base of connexival spine arising from beneath the dorsal edge of seventh connexivum, the transverse base of connexival spines overlapping the rear margin of seventh abdominal segment on either side. Connexival spines long, their tips attaining the tips of dorsolateral lobe. Where the transverse base of the spine turns caudally the spine turns obliquely upward for about one-third of its length before turning caudally. Without or with only the faintest indication of a ventrolateral lobe of the seventh abdominal segment. Dorsolateral lobe of seventh abdominal segment long, its upper margin nearly straight.

* Measurements of the male type were made by Mr. R. J. Izzard of the British Museum.

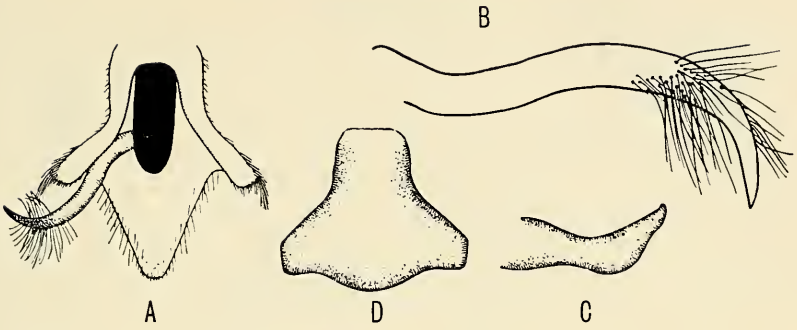


Fig. 133. *Ptilomera laticaudata* Hardw. ♂.
A Genitalkapsel von oben; B linker Genitalgriffel; C Griffelende von der Spitze aus gesehen; D Analplatte.
Nach der Type aus Nepal.

Fig. 1. Dr. Lundblad permitted us to use this figure which illustrates the male genital characters of one of the types in the British Museum.

Comparative notes: We have long considered some specimens from Assam as this species. However, we now can separate both sexes of it from *P. laticaudata* (Hardw.) and regard the specimens from Assam as a new species.

Types: Two male types from Nepal are in the British Museum. One neallotype from "Singla Darjiling, E. Himalayas, June 13, 1500 ft. Ld. Carmichael" is in the Torre-Bueno Collection at K. U.

Distribution: In addition to the above we have seen two females and one male bearing the label "Sikkim, Gopaldhara, Rungbon. Vall. H. Stevens." These are like the neallotype above and are in the British Museum.

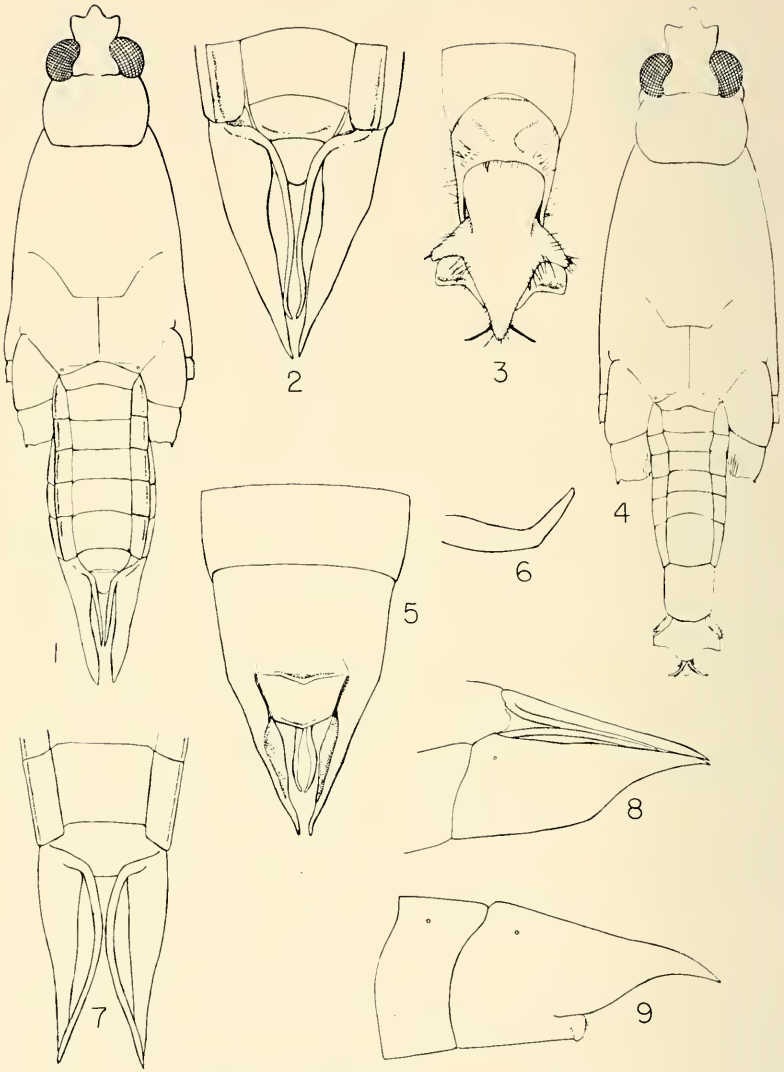
Ptilomera (*Ptilomera*) *assamensis* n. sp.

Plate IV

Size: Male, (apterous): Length 13.8 mm.; width of head 2.00 mm.; width of pronotum 2.33 mm.; length of mesonotum 3.29 mm.; greatest width of body across mesoacetabula 3.81 mm.

Female (apterous): Length 14.29 mm.; width of head 2.05 mm.; width of pronotum 2.19 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.90 mm. As we have stated in "Taxonomic Problems Involved," we will not hereafter give figures or size variation, but the following will illustrate the problem by this species. Length of apterous males ranges from 13 to 15 mm.; width of head 1.85 to 2.00 mm.; width of prothorax 1.97-2.27 mm.;

PLATE IV



Ptilomera (*Ptilomera*) *assamensis* n. sp.

FIG. 1. Female, dorsal view.

FIG. 2. Female, dorsal view of sixth and seventh abdominal segments.

FIG. 3. Male, ventral view of genital segments.

FIG. 4. Male, dorsal view.

FIG. 5. Female, ventral view of sixth and seventh abdominal segments.

FIG. 6. Arm of right paramere as seen from the rear.

FIG. 7. Female, dorsal view of sixth and seventh abdominal segments. This specimen has a hand written label "Karwapam." Its connexival spines are unusually long.

FIG. 8. Female, an oblique view to show the flat lying connexival spines.

FIG. 9. Female, side view of sixth and seventh abdominal segments.

greatest width of body across mesoacetabula 2.73-3.81 mm. Length of apterous females ranges from 13.90-14.88 mm.; width of head 1.89 to 2.05 mm.; width of prothorax 1.87-2.14 mm.; greatest width of body across mesoacetabula 3.36 to 3.99 mm.

There are other species with even greater variations in size.

Color: Ground color yellowish to reddish brown, abdominal tergites, except the last one, may be black in the males or brown with only the lateral margins and intersegmental lines black, connexivum brown. Clypeus black, two narrow black converging lines on vertex. Anterior median margin of pronotum with two black spots or a continuous connecting line between them behind the interocular space. Anterior margin of mesonotum with a lateral black spot on either side. Sides of mesothorax usually with two longitudinal undulate dark bands separated by a band of silvery pile above a yellow streak. The upper band black, the lower one dark brown and sometimes incomplete. Venter pale yellow, covered by a short silvery pile. Antennae, front tibia and tarsus dark brown. Front femur with three dark brown to black longitudinal bands; legs elsewhere light brown.

Structural characteristics: Relative length of antennal segments. Most specimens have lost at least the last two segments. There is a male in the British Museum labeled "Assam, W. F. Badgley 1906-185." This has the left antenna entire and measures: 1st:2nd:3rd:4th::175:37.5:55:32.5. and a female from the same place with the right antenna entire, 1st:2nd:3rd:4th::132.5:28.5:43:28.5.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	8.33 mm.	7.14 mm.	3.86 mm.	1.81 mm.
Female	7.38 mm.	6.33 mm.	3.71 mm.	1.52 mm.

Middle leg	Femur	Hind leg	Femur
Male	21.66 mm.	Male	27.38 mm.
Female	19.87 mm.	Female	22.97 mm.

Male. Length of pregenital abdominal segments:Genital segments::77:48. Genital segments: Suranal plate with median lobe broad, but as long as or longer than the distal width of a lateral wing and more obviously surpassing the lateral wings caudally than in *P. laticaudata* (Hardw.); front and rear margins of lateral wings not parallel. Pygofer relatively short, its tip roundly pointed, its dorsolateral projections short and broad at base as seen ventrally. Paramere with much of its shaft hidden beneath the median lobe, its exposed part superficially resembling that of *P. laticaudata.*

However, the distal half of the arm as seen from the rear lacks the definite constriction that Lundblad showed for *P. laticaudata* (Hardw.).

Female. Length of thorax:Abdomen::121:143. Seventh abdominal tergite with rear margin appearing broadly rounded and much shorter than the sixth tergite. Base of connexival spine arising from beneath the base of seventh connexivum as a swelling that leaves no connexival edge. The obliquely turned base of connexival spine but slightly overlaps the caudolateral edge of the seventh tergite, then turns caudally and lies flat to its tip which seldom reaches tip of dorsolateral lobe. Without or with only the faintest indication of a ventrolateral lobe of the seventh abdominal segment. Dorsolateral lobe of seventh abdominal segment long but not a straight line.

Comparative notes: A close relative of *P. laticaudata* but separated from it as shown in the key.

Types: Male holotype and female allotype and one male and one female paratype from "Assam. W. F. Badgley 1906" and one female paratype "Karwapaui 1907" are in the British Museum. We have in the K. U. Collection the following paratypes: 4 ♂ ♂, 3 ♀ ♀ from "Assam, India," and 3 ♂ ♂ and 1 ♀ labeled "Assam" that came to us in the Kirkaldy Collection.

Distribution: Known only from the type localities.

Ptilomera (*Ptilomera*) *sarawakensis* n. sp.

Plate V

Size: Male holotype (apterous). Length 16.19 mm.; width of head 2.38 mm.; width of pronotum 2.48 mm.; length of mesonotum 3.76 mm.; greatest width of body across mesoacetabula 4.19 mm.

Female allotype (apterous). Length 17.71 mm.; width of head 2.29 mm.; width of pronotum 2.38 mm.; length of mesonotum 3.90 mm.; greatest width of body across mesoacetabula 4.48 mm.

Male (macropterous). Length with wings 17.38 mm.; width of head 2.29 mm.; width across humeri 3.33 mm.; greatest width of body across mesoacetabula 3.86 mm.

Female (macropterous). Length of body without wings 16.90 mm.; width of head 2.19 mm.; width across humeri 3.05 mm.; greatest width of body across mesoacetabula 3.86 mm.

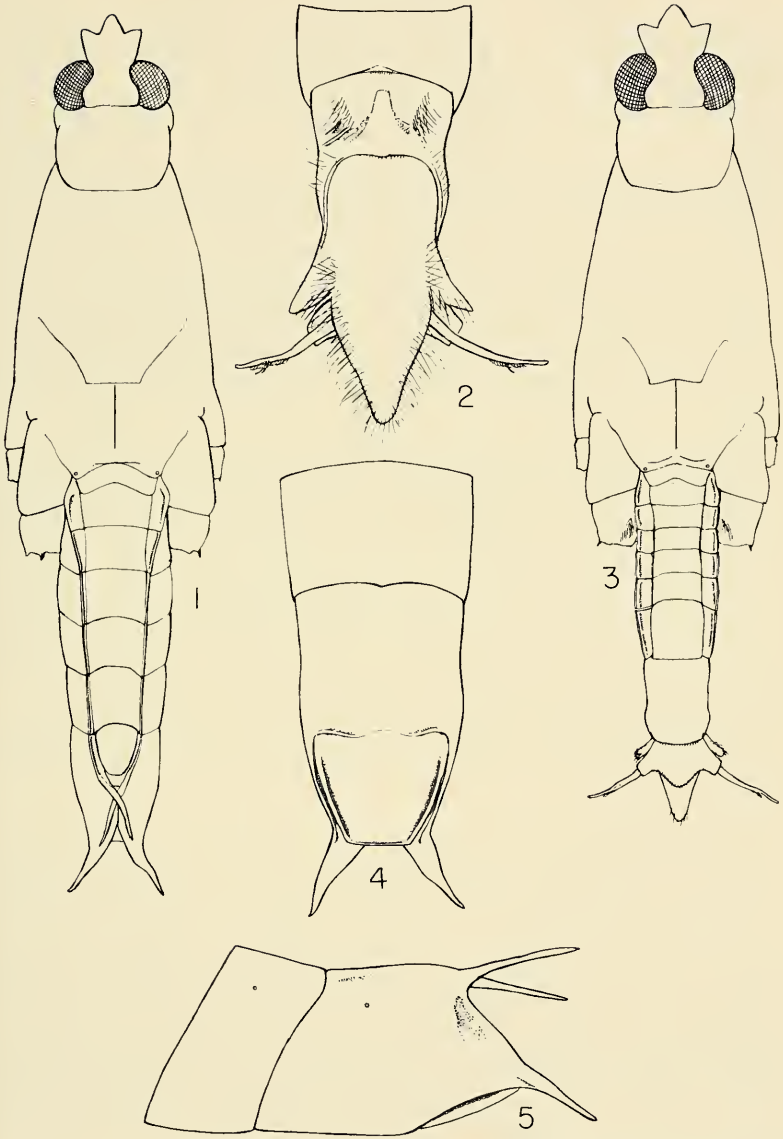
Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male holotype 1st:2nd:3rd:4th::180:40:59:37.

Female allotype 1st:2nd:3rd:4th::162:35:48:38.

PLATE V



Ptilomera (*Ptilomera*) *sarawakensis* n. sp.

FIG. 1. Female allotype, dorsal view.

FIG. 2. Male holotype, ventral view of genital segments.

FIG. 3. Male holotype, dorsal view. Note the long first genital segment, the median lobe of suranal plate and the long parameres.

FIG. 4. Female allotype, ventral view of thee sixth and seventh abdominal segments.

FIG. 5. Female allotype, side view of sixth and seventh abdominal segments.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	9.42 mm.	8.24 mm.	4.76 mm.	1.86 mm.
Female	8.91 mm.	7.71 mm.	5.1 mm.	

Middle leg	Femur	Hind leg	Femur
Male	26.1 mm.	Male	30.48 mm.
Female	23.47 mm.	Female	27.86 mm.

Male. Length of pregenital abdominal segments:Genital segments::87:67. Suranal plate with median lobe rather broad and extending caudally beyond the short lateral wings which have their front and rear margins not parallel. Pygofer of usual shape. Dorsolateral projections, as seen from below, broad at base but nearly pointed; as seen from above about as long as lateral lobe of suranal plate. Paramere long, shaft and arm not distinguishable. See plate 5, fig. 2.

Female. Length of thorax:Abdomen::145:180. Seventh abdominal tergite nearly as long as sixth tergite (18.5:17.8). Connexival spine moderately short, arising from end of the curved edge of the seventh connexivum, thus the connexival spines have a tendency to cross each other, without or with only the faintest indication of a ventrolateral lobe of seventh segment; dorsolateral lobe of seventh abdominal segment long. Sides of the vertically directed distal lobe of seventh abdominal sternite not straight and parallel, but curved and distally converging toward the truncated distal end.

Comparative notes: This species runs out with *P. laticaudata* (Hardw.) in both keys to the sexes, couplet 9 for males and couplet 32 for females.

Types: Holotype apterous male, allotype apterous female bear the label "Sarawak:Mt. Dulit R. Koyan 2500 ft. Primary Forest Nov. 13, 1932." "On surface of fast water." Also a macropterous male bearing the above label; a macropterous female from the above locality but taken at 850 ft. on Aug. 22, 1932; an apterous female taken "skating on slow moving water at the junction of Tinjar and Lejok rivers at foot of Mt. Dulit Aug. 15, 1932; another apterous female "on fast parts of stream on Dulit Trail Aug. 16, 1932." All of the above are labeled "paratypes" and were taken by B. M. Hobby and A. W. Moore on the Oxford Univ. Exp. The types are in the British Museum.

Distribution: Known only from the above type localities. The finding of a specimen "on slow moving water" is only known such record. *Ptilomera* are usually recorded from fast moving water as were the other specimens of this type series.

Ptilomera (*Ptilomera*) *cingalensis* Stål

Plate VI

1855. *Ptilomera cingalensis* Stål, Öfvers af K. Vet. Akad. Förh. 12, 190 (Described from "Ins. Taphrobana" an ancient name of Ceylon).
1927. *Ptilomera cingalensis*, Esaki, Eos Rev. Esp. Ent. 3(3):259.
1933. *Ptilomera cingalensis*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 373, 421.
1933. *Ptilomera canace* Schmidt, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12: 372, 373, 421 (Says is a synonym of *P. cingalensis* Stål, with which we agree).
1960. *Ptilomera cingalensis*, Matsuda, Univ. Kansas Sci. Bull. 41(2):267.

Since *P. canace* Schmidt 1926 is a synonym of *P. cingalensis* Stål 1855 the following references belong here:

1926. *Ptilomera canace* Schmidt, Ent. Mitt. 15(1):65 (Described male and female from Ceylon).
1927. *Ptilomera canace*, Esaki, Eos Rev. Esp. Ent. 3(3):259.
1960. *Ptilomera canace*, Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 539 fig. 626.

Dr. Lundblad found the type, a female in the Riksmuseet in Stockholm and also a male that Stål did not describe. However, Lundblad did not describe either sex but stated that it is a species that can be recognized as such. We have not seen the type of *P. cingalensis* but since Lundblad placed *P. canace* Schmidt as a synonym of *P. cingalensis* Stål (they both came from Ceylon) and we have studied four types of *P. canace* Schmidt (1 male and 1 female with their genital segments mounted on slides and two others). We know our specimens from Ceylon are *P. cingalensis* and offer the following description of the species.

Size: This ceylonese species is indeed variable in size. The males ranging from 12.14 mm. to 16.66 mm. in length, and females from 12.0 mm. to 15.0 mm. The pair we have chosen from our Kirkaldy Collection have the following measurements:

Male (apterous): Length 16.66 mm.; width of head 2.40 mm.; width of pronotum 2.67 mm.; length of mesonotum 3.43 mm.; greatest width of body across mesoacetabula 4.38 mm.

Female (apterous): Length 14.0 mm.; width of head 2.1 mm.; width of pronotum 2.1 mm.; length of mesonotum 2.9 mm.; greatest width of body across mesoacetabula 3.86 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments: Male from Pundaluoya, Ceylon, 1st:2nd:3rd4th::160:40:50:34.
Female from Pundaluoya, Ceylon, 1st:2nd:3rd:4th::138:32:41:30.
The male type of *P. canace* Schmidt has only two basal antennal segments: 1st:2nd::154:40. One of our males from Pundaluoya,

Ptilomera (*Ptilomera*) *cingalensis* Stål

Fig. 1. Female from Pundaluoya, Ceylon. Dorsal view.

Fig. 2. Male from Pundaluoya, Ceylon. Ventral view of genital segments.

Fig. 3. Female from Pundaluoya, Ceylon. Ventral view of sixth and seventh abdominal segments.

Fig. 4. Male from Pundaluoya, Ceylon. Dorsal view. Note carefully the shape of suranal plate, caudal end of pygofer and shape of paramere.

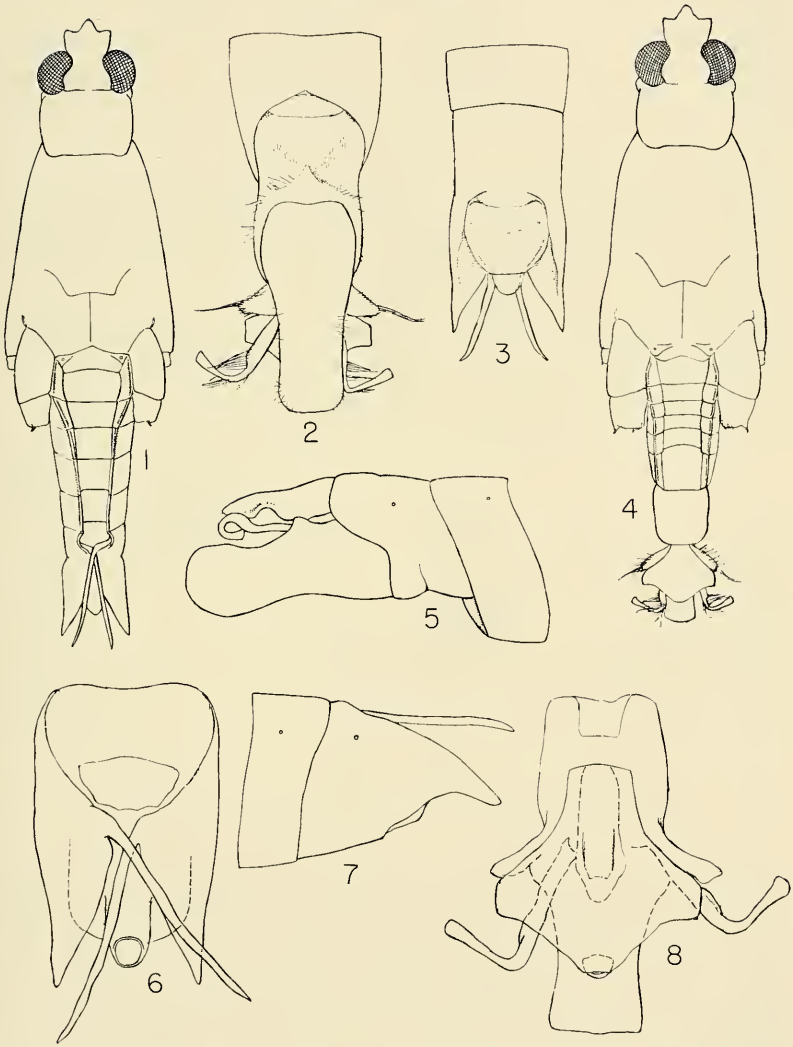
Fig. 5. Right side view of genital segments of above male.

Fig. 6. *Ptilomera canace* Schmidt, female type. Dorsal view of seventh abdominal segment drawn from the slide mount.

Fig. 7. *Ptilomera cingalensis* Stål. Female from Pundaluoya, Ceylon. Left side view of sixth and seventh abdominal segments.

Fig. 8. *Ptilomera canace* Schmidt. Male type. Last genital segment drawn from the slide mount.

PLATE VI



Ceylon with only two basal segments 1st:2nd::178:43 which shows a considerable variation.

Actual Lengths of Leg Segments (Pair from Pundaluoya, Ceylon)

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	9.43 mm.	8.19 mm.	4.95 mm.	1.81 mm.
Female	7.00 mm.	6.24 mm.	3.57 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male	25.47 mm.	Male	33.81 mm.
Female	19.19 mm.	Female	21.67 mm.

The measurements of the types of *P. canace* Schmidt are as follows:

Male (apterous): Length without genital segments 11.76 mm.; width of head 2.38 mm.; width of pronotum 2.57 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.90 mm.

Female (apterous). Length 13.0 mm.; width of head 2.05 mm.; width of pronotum 2.05 mm.; length of mesonotum 2.86 mm.; greatest width of body across mesoacetabula 3.67 mm.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	9.19 mm.	7.67 mm.	4.76 mm.	
Female	7.14 mm.	6.19 mm.	2.95 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male	24.76 mm.	Male	31.90 mm.
Female	19.05 mm.	Female	22.38 mm.

Male. Length of pregenital abdominal segments:Genital segments::80:77. Suranal plate with median lobe broad, surpassing lateral wings caudally; lateral wings short, their anterior and posterior margins not parallel. Pygofer with its dorsolateral projection stout, slightly before its middle, and about as long as lateral lobes of the suranal plates as seen from above; apical margin of pygofer broad, truncate; lateral margins of pygofer beyond lateral projections parallel or nearly parallel as seen from below; as seen from the side ventral line of pygofer medially curved upward, making a constriction. Paramere as seen from above with most of its shaft hidden by median lobe of suranal plate, its arm turned laterad and its tip spatulate and broad. Distal part of dorsum of first genital segment but slightly elevated as seen in side view, its venter transversely constricted.

Female. Length of thorax:Abdomen::114:135. Seventh abdominal tergite much shorter than sixth. Connexival spine long, arising

from base of connexivum of seventh segment, turned medially and then caudally as a long spine. Dorsolateral lobe of seventh abdominal segment long, its tip plainly surpassing ninth abdominal tergite when visible. Upper margin of dorsolateral lobe of seventh abdominal segment definitely curved. In side view appearing short, without or with only the slightest indication of ventrolateral lobe.

Comparative notes: The males of this species have the apical margin of the pygofer broad as do *P. chinai* and *P. timorensis* from which they are separated as shown in the key. The females have the base of connexival spine arising from beneath the dorsal edge of the dorsolateral lobe of the seventh segment at its base and directed medially then caudally. This is true of *P. agriodes* Schmidt and *P. laticaudata* Hardwicke from which they are separated as shown in our key couplet 31.

Types: The type of *P. cingalensis* Stål is in the Riksmuseet at Stockholm, Sweden. The types of *P. canace* Schmidt, one male and three females are now in the Polish Academy of Sciences in Warsaw.

Distribution: The type of both *P. cingalensis* Stål and *P. canace* Schmidt came from Ceylon without a definite locality. We have before use the following:

"Ceylon, Pundaluoya Ap. '98 (from rocky stream)" 1 ♂;

"Ceylon, Pundaluoya May '97 (from rocky stream)" 1 ♀;

"Ceylon, Pundaluoya, Aug. '97 (from rocky stream)" 4 ♂ ♂, 3 ♀ ♀. The above is from the Kirkaldy Collection, University of Kansas. "Ceylon, Suduganga River, Matale R. A. Senior-White" 1 ♀ (Torre-Bueno Collection, K. U.); "Ceylon, Pitamba Ela Jan. 26, 1958, K. L. A. Perera" 1 ♂ 2 ♀ ♀; "Ceylon, Nindoma, Jan. 27, 1958 K. L. A. Perera" 3 ♀ ♀ (K. U.).

Ptilomera (*Ptilomera*) *agriodes* Schmidt

Plate VII

1926. *Ptilomera agriodes* Schmidt, Ent. Mitt. 15(1):63-4.
1927. *Ptilomera agriodes*, Esaki, Eos Rev. Esp. Ent. 3(3):259.
1933. *Ptilomera agriodes*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:371, 373, 421.
1933. *Ptilomera lachne* Schmidt, Lundblad, Arch. Hydrobiol Suppl. 12:372, 373, 419 (Said is female of *P. agriodes* Schmidt).
1960. *Ptilomera agriodes*, Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 537 fig. 612,613 (wings) fig. 618 (hind tarsus showing two segments that are fused).

Since *P. lachne* Schmidt is a synonym, the following references also go here.

1926. *Ptilomera lachne* Schmidt, Ent. Mitt. 15(1):64 (Described female from Tranquebar, S. India).
1927. *Ptilomera lachne*, Esaki, Eos Rev. Esp. Ent. 3(3):259.
1960. *Ptilomera lachne* Matsuda, Univ. Kansas Sci. Bull. 41(2):267.

PLATE VII

Ptilomera (*Ptilomera*) *agriodes* Schmidt

FIG. 1. Female from Anamalai Hills, S. India. Dorsal view.

FIG. 2. Male from S. India, ventral view of genital segments. Note the large elongate dorsolateral projections of the pygofer.

FIG. 3. Caudal portion of pygofer of above male seen from the left side.

FIG. 4. Dorsal view of above male. Note the shape of suranal plate, the dorsally turned up tip of pygofer, the huge dorsolateral projections of pygofer and the more slender curved parameres.

FIG. 5. Female of figure 1. Ventral view of sixth and seventh abdominal segments. This does not show the true shape of the distal median lobe of the seventh ventrite.

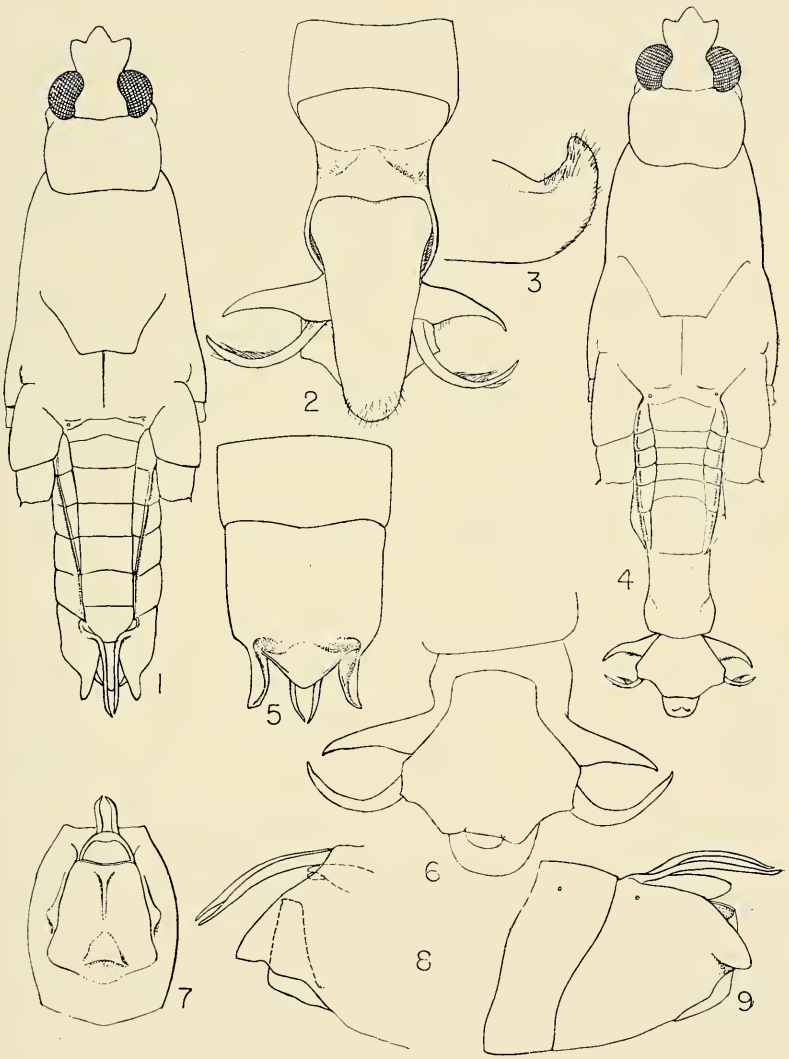
FIG. 6. Male type of *P. agriodes*. Drawing made of the second genital segment in a slide mount.

FIG. 7. Female of figure 1. Abdominal end as seen from the rear to show the true shape of the distal median lobe of the seventh ventrite.

FIG. 8. The seventh abdominal segment of *P. lachne* Schmidt type, drawn from a slide showing right side.

FIG. 9. Shows the sixth and seventh abdominal segments of a female of *P. agriodes* Schmidt seen from left side.

PLATE VII



Redescription based on an apterous male type from Trichinopoli, South India, and on apterous female type of *P. lachne* Schmidt from Tranquebar, S. India.

Size: Male (apterous): Length 17 mm.*; width of head 2.57mm.; width of pronotum 3.1 mm.; greatest width of body across mesoacetabula 5.0 mm.

Female (apterous). Length 14.00 mm.; width of head 2.33 mm.; width of pronotum 2.52 mm.; length of mesonotum 3.33 mm.; greatest width of body across mesoacetabula 4.52 mm.

Color: Quite typical for the genus. Ground color brown with usual black markings. Side of thorax with a black longitudinal band that is divided by a reddish yellow undulate line leading forward from mesothoracic spiracle.† Venter covered by a silvery pile. Antennae black, with last two segments more or less covered by a silvery pile. Legs dark brown. Front femur with a black longitudinal band on each side, its venter dark brown but more or less covered with a silvery pile. Tibia and tarsus nearly black but covered also with a silvery pile. Middle and hind legs dark brown, with distal end of tibia and tarsus light brown and covered with silvery pile.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::175:40:50:36.4.
Female: 1st:2nd:3rd:4th::144:30:40:31.

Relative Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	9.52 mm.	8.24 mm.	5.00 mm.	2.05 mm.
Female	8.19 mm.	6.81 mm.	3.95 mm.	1.76 mm.

Middle leg	Femur	Hind leg	Femur
Male	24.29 mm.	Male	29.76 mm.
Female	21.33 mm.	Female	23.81 mm.

The front femur of male rather stout, 1.47 mm. in diameter, with usual incised place on under side of distal end that is smooth and shiny, with two black shiny transverse protuberances near its middle and at its base a conical less prominent tubercle. Front tibia also has at its inner base a similar incised area with three black shiny elevations, it is rather stout, as wide as middle femur (0.76 mm.); tarsus much more slender, outer lobe of terminal cleft of second tarsal segment much shorter than inner lobe. Middle femur stouter but shorter than hind femur. More than distal half of middle femur

* Length as given by Schmidt in his description. We found that the genital segments of all types had been removed and cleared and mounted in balsam.

† This yellow line is usually obscured by a band of silvery hairs.

with a dense brush of long hairs; basal part of middle femur with short inconspicuous hairs. Metasternum of male short, subequal to first two visible abdominal ventrites * together; of female metasternum subequal to first visible abdominal ventrite.

Male. Length of pregenital segments:Genital segments::102:70. Suranal plate with median lobe broadly rounded, its caudolateral margins undulate and extending caudally far beyond short lateral wings, lateral margins of which are nearly parallel, with caudolateral corner of wings slightly protruded. Pygofer with dorsolateral projections that surpass lateral wings of suranal plate by half their length, their tips pointed and turned caudally, caudal end of pygofer as seen from above broadly rounded, as seen from side or rear turned up and pointed. Paramere long, its arm curved laterally and its tip pointed and turned forward.

Female. Length of thorax:Abdomen::136:176. Seventh abdominal tergite a little longer than sixth tergite. Connexival spine arising beneath incured edge of connexivum, turned medially then caudally, its tip reaching caudal end of dorsolateral lobe that is short, broad and directed obliquely downward. Ventrolateral lobe very slightly developed. Distal lobe of seventh sternite turned dorsally and exposed, with a median longitudinal carina, its lateral margins slightly converging caudally and its tip or distal edge transverse and slightly concave as seen from rear.

Comparative notes: The long dorsolateral projections of pygofer separate this species from all others. The female has the base of the connexival spine arising from beneath the connexival edge of the seventh abdominal segment near its base. The dorsolateral lobe of seventh abdominal segment short, its tip only slightly surpassing ninth tergite when visible, and this separates it from *P. cingalensis* which has the dorsolateral lobe of seventh abdominal segment long.

Types: The type of *P. agriodes* Schmidt is an apterous male from Trichinopoli, South India and the type of *P. lachne* Schmidt is an apterous female from Tranquebar. Both are now in the Polish Academy of Sciences in Warsaw, Poland.

Distribution: We have both males and females from a single place in South India that are like types. Besides the type we have seen the following: "South India Feb. 1955 P. S. Nathan" "Shovaroy Hill, Nagalur 4000 ft." 5 ♀ ♀ (deälated) K. U. Coll.; "South India Feb. 1955 P. S. Nathan" "Shovaroy Hill, Yorcaud 4500 ft." 1 ♂ deälated), 8 apterous ♂ ♂, 9 macropterous ♀ ♀ (K. U. Coll.);

* The first abdominal ventrite is absent in this genus.

"South India Anamalai Hills, Cinchona 3500 ft. Apr. 1957 P. S. Nathan" 4 macropterous ♂♂, 4 macropterous ♀♀; 9♂♂, 18♀♀ (deälated); 3♂♂ and 13♀♀ (apterous) (K. U. Coll.). From the same locality in May 1957, 1♀ (deälated) (K. U. Coll.); "India Coimbatore Dist. Nilgiri Hill, Kollor Susai Nathan" 1♂ 1♀ (apterous) (Mus. Nat. Hist. Basel, Switzerland).

Ptilomera (*Ptilomera*) *timorensis* n. sp.

Plate VIII

Size: Male (apterous): Length 15.1 mm.; width of head 2.31 mm.; width of pronotum 2.57 mm.; length of mesonotum 3.95 mm.; greatest width of body across mesoacetabula 4.00 mm. Female (apterous). Length 14.05 mm.; width of head 2.1 mm.; width of pronotum 2.57 mm.; length of mesonotum 3.95 mm.; greatest width of body across mesoacetabula 4.00 mm.

Color: Only head and pronotum with the typical ground color of reddish brown; Meso- and metonotum dark brown to black; first six abdominal tergites black, seventh may be reddish brown; genital segments paler; in all of the specimens the silvery pile bands and spots are confined to the sides. The venter with the usual short silvery pile. The typical pattern of black markings not distinguishable.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::153:35:42:31.
Female: 1st:2nd:3rd:4th::120:28:35:27.

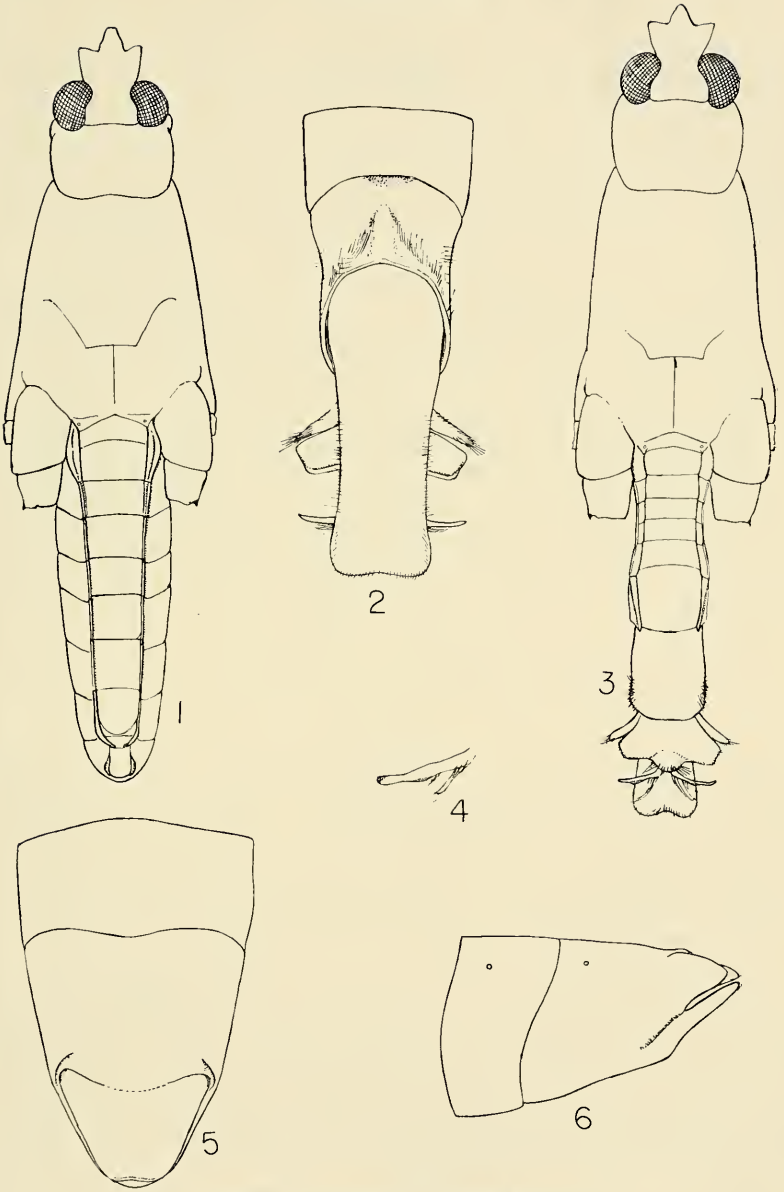
Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male (paratype)	7.77 mm.	6.81 mm.	3.71 mm.	1.57 mm.
Female (paratype)	6.57 mm.	5.48 mm.	3.33 mm.	1.38 mm.

Middle leg	Femur	Hind leg	Femur
Male (paratype)	22.14 mm.	Female (paratype)	17.14 mm.
Male (paratype)	27.14 mm.	Female (paratype)	19.05 mm.

Male. Length of pregenital abdominal segments:Genital segments::86:84. Genital segments: Suranal plate with median lobe not broad but surpassing caudally the short broad lateral wings, the anterior and posterior margins of which are not parallel. Pygofer of unusual shape, quite uniformly broad, its apical margin broad with a median incission or notch, dorsolateral projections of pygofer short and slender. Shaft of paramere rather slender but almost entirely hidden by the median lobe of suranal plate. The arm is long.

PLATE VIII



Ptilomera (*Ptilomera*) *timorensis* n. sp.

FIG. 1. Female allotype, dorsal view.
FIG. 2. Male holotype, ventral view of genital segments.
FIG. 3. Male holotype, dorsal view.
FIG. 4. Male holotype, arm of left paramere.
FIG. 5. Female allotype, ventral view of sixth and seventh abdominal segments.
FIG. 6. Female allotype, side view of sixth and seventh abdominal segments.

Female. Length of thorax:Abdomen::110:128. Seventh abdominal tergite a little longer than the sixth. Connexival spines very short, inconspicuous, arising from end of connexivum and turned medially but too short for their tips to meet. Dorsolateral lobe short and broad at base without or with only the faintest indication of a ventrolateral lobe of seventh abdominal segment. Distal lobe of seventh abdominal sternite entirely exposed and not turned dorsally, its lateral margins nearly straight but converging, distal end slightly rounded as shown on Plate VIII fig. 5.

Comparative notes: This striking species is so different from any other that it can be recognized by anyone. The males by the broad pygofer with its distal margin at least slightly bi-lobed and the female by its very short connexival spines.

Types: This apterous type series consists of holotype male bearing the label, "Timor, Baaguia, August 1935. C. Bühler u. Meyer." Allotype with the label, "Timor Soe. June 1, 1935 C. Bühler u. Meyer." Paratypes from Timor Soe 2 ♂ ♂, and 1 ♂ labeled "Timor." Kirkaldy Coll. in K. U. Holotype allotype and 1 ♂ and 1 ♀ paratypes are in Basel Museum, Switzerland and one pair in K. U. collection.

Distribution: Known only by the type localities.

Ptilomera (*Ptilomera*) *chinai* n. sp.

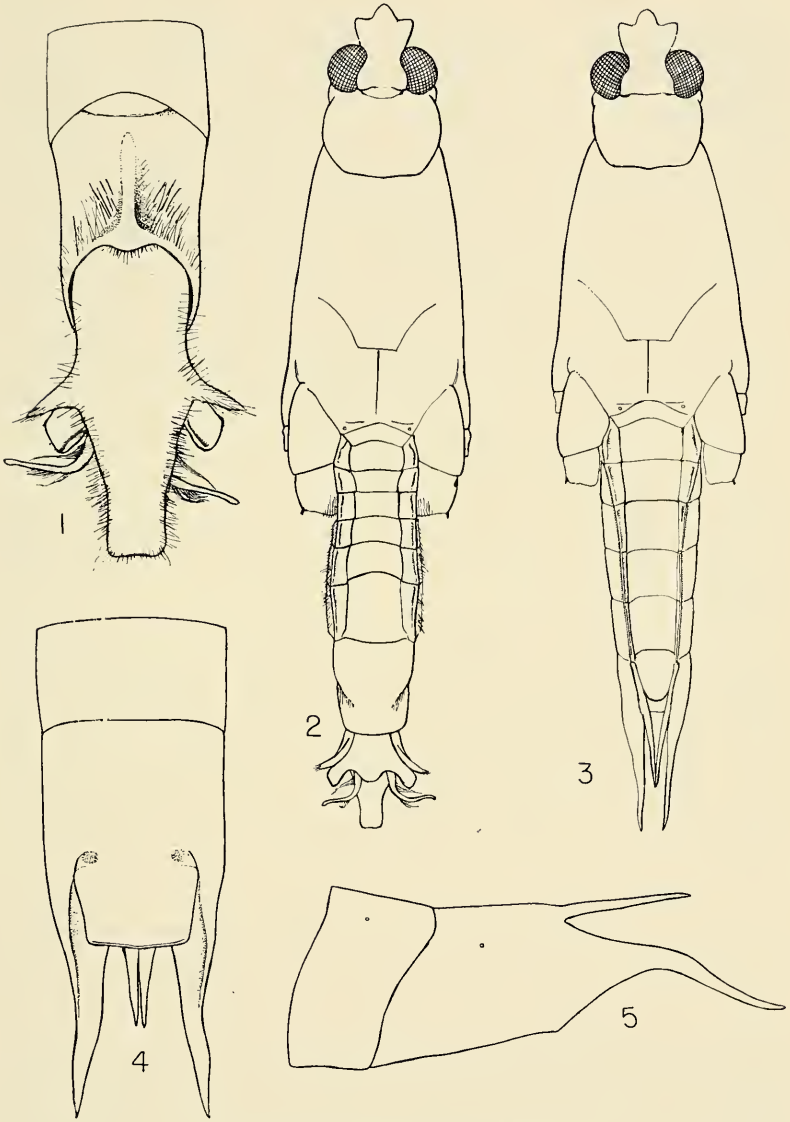
Plate IX

Size: Male (apterous): Length 17.14 mm.; width of head 2.38 mm.; width of pronotum 2.52 mm.; length of mesonotum 3.57 mm.; greatest width of body across mesoacetabula 3.90 mm. Female (apterous). Length 17.62 mm.; width of head 2.24 mm.; width of pronotum 2.29 mm.; length of mesonotum 3.52 mm.; greatest width of body across mesoacetabula 4.14 mm.

Color: Pattern typical for the genus. In these two specimens more of the ground color is exposed because the black areas are small. Vertex with two converging black stripes. The neck crossed by a black band; anterior margin of pronotum with a faint, dark band; two narrow longitudinal black lines on side of the meso- and metathorax separated by a broader band of ground color, which is not densely covered by silvery pile.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::164:38:53: ?.
Female: 1st:2nd:3rd:4th::145:32: ?: ?.

PLATE IX



Ptilomera (*Ptilomera*) *chinai* n. sp.

FIG. 1. Ventral view of genital segments of male holotype.

FIG. 2. Apterous male holotype.

FIG. 3. Apterous female allotype.

FIG. 4. Ventral view of sixth and seventh abdominal segments of female allotype.

FIG. 5. Female allotype, left side view of sixth and seventh abdominal seg-

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male (holotype)	8.67 mm.	7.33 mm.	4.48 mm.	
Female (allotype)	8.05 mm.	7.10 mm.	6.76 mm.	1.62 mm.

Middle leg	Femur	Hind leg	Femur
Male (holotype)	25.95 mm.	Male (holotype)	28.60 mm.
Female (allotype)	22.76 mm.	Female (allotype)	26.19 mm.

Male (holotype). Length of pregenital abdominal segments: Genital segments::92:89. Genital segments: Median lobe of suranal plate moderately broad; lateral wings well developed, thickened toward their ends; their front and rear margins not parallel because the rear margin of basal half of the lateral wing of suranal plate concave, the wings surpass caudally the median lobe. Pygofer, as seen from below, with its lateral margins beyond the dorsolateral projections parallel or nearly so. Pygofer truncate (or slightly medially concave) at tip. Dorsolateral projections of pygofer as seen from above short, a little longer than the lateral wings of the suranal plate and rather pointed. Paramere long, the exposed shaft short, the long arm curved laterally, its blunt tip slightly turned caudally. The first genital segment with a distinct median longitudinal keel on its venter.

Female. Length of thorax:Abdomen::135:192. Seventh abdominal tergite only slightly shorter than sixth tergite. Moderately long connexival spines arise at end of connexivum. Dorsolateral lobe long, its base a long triangular lobe that becomes cylindrical, slightly sigmoid on upper margin and spine like. Ventrolateral lobe absent or very faintly indicated. Sides of the usually vertically directed distal lobe of the seventh abdominal sternite nearly straight and nearly parallel.

Comparative notes: Of the five species described from Borneo this is the only one in which the males have a pygofer with a broad nearly truncate tip and the females with a long dorsolateral lobe that is slightly sigmoid on upper margin, as seen laterally.

Types: Male holotype and female allotype both apterous, bear the label "Sambas Borneo (West Coast)." "C. J. Brooks, B. M. 1936-681." These are in the British Museum. Two paratypes, also apterous, are in the Bernice Bishop Museum in Hawaii. They bear the label "Borneo: Sarawak Kuching, Santubong 797 to 1500 m. June, 18-30, 1958. T. C. Maa, Collector No. M. B.-78" 1 ♂, 1 ♀.

Distribution: Known only from the type localities.

This species is named in honor of Dr. W. E. China of the British Museum.

Ptilomera (*Ptilomera*) *nunikanensis* n. sp.

Plate X

Size: Male holotype (apterous): Length 14.52 mm.; width of head 2.19 mm.; width of pronotum 2.33 mm.; length of mesonotum 3.24 mm.; greatest width of body across mesoacetabula 3.43 mm.?

Female allotype (apterous): Length 15.48 mm.; width of head 2.05 mm.; width of pronotum 2.05 mm.; length of mesonotum 3.23 mm.; greatest width of body across mesoacetabula 3.57 mm.?

Color: Both specimens are teneral and the ground color nearly testaceous and black areas reduced. However, the pattern is typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::152:34:48:31.

Female: 1st:2nd:3rd:4th::145:30.5:?:?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	8.10 mm.	6.57 mm.	3.95 mm.	1.57 mm.
Female	7.62 mm.	6.29 mm.	4.00 mm.	1.57 mm.

Middle leg	Femur	Hind leg	Femur
Male	21.52 mm.	Male	25.47 mm.
Female	20.00 mm.	Female	21.91 mm.

Male holotype. Length of pregenital abdominal segments:Genital segments::82:82. Genital segments: Suranal plate with median lobe small, lateral wings well developed and plainly surpassing median lobe caudally. Pygofer as seen from below conspicuously broad beyond the middle. Caudal half of that section of pygofer beyond its dorsolateral projections parallel sided. As seen laterally this distal portion is turned dorsally to a truncate tip as shown on plate X fig. 7. Dorsolateral projection of pygofer stout and extends laterally farther than the wing of suranal plate. The paramere stout, its shaft short, its arm long and of characteristic shape as shown on plate X fig. 4.

Female. Length of thorax:Abdomen::125:158. Seventh abdominal tergite about as long as sixth tergite. Connexival spine long, arising at end of connexivum. Dorsolateral and ventrolateral lobes separated by a narrow incision. Ventrolateral lobe sharp pointed.

Comparative notes: This species is quite distinct from other species of *Ptilomera* from Borneo.

Types: Holotype (apterous male) and allotype (apterous female) bear the labels "Nunikan 1. E. Kalimantan Dist. Indonesian

Ptilomera (*Ptilomera*) *nunikanensis* n. sp.

FIG. 1. Male holotype, dorsal view.

FIG. 2. Female allotype, ventral view of sixth and seventh segments.

FIG. 3. Female allotype, dorsal view.

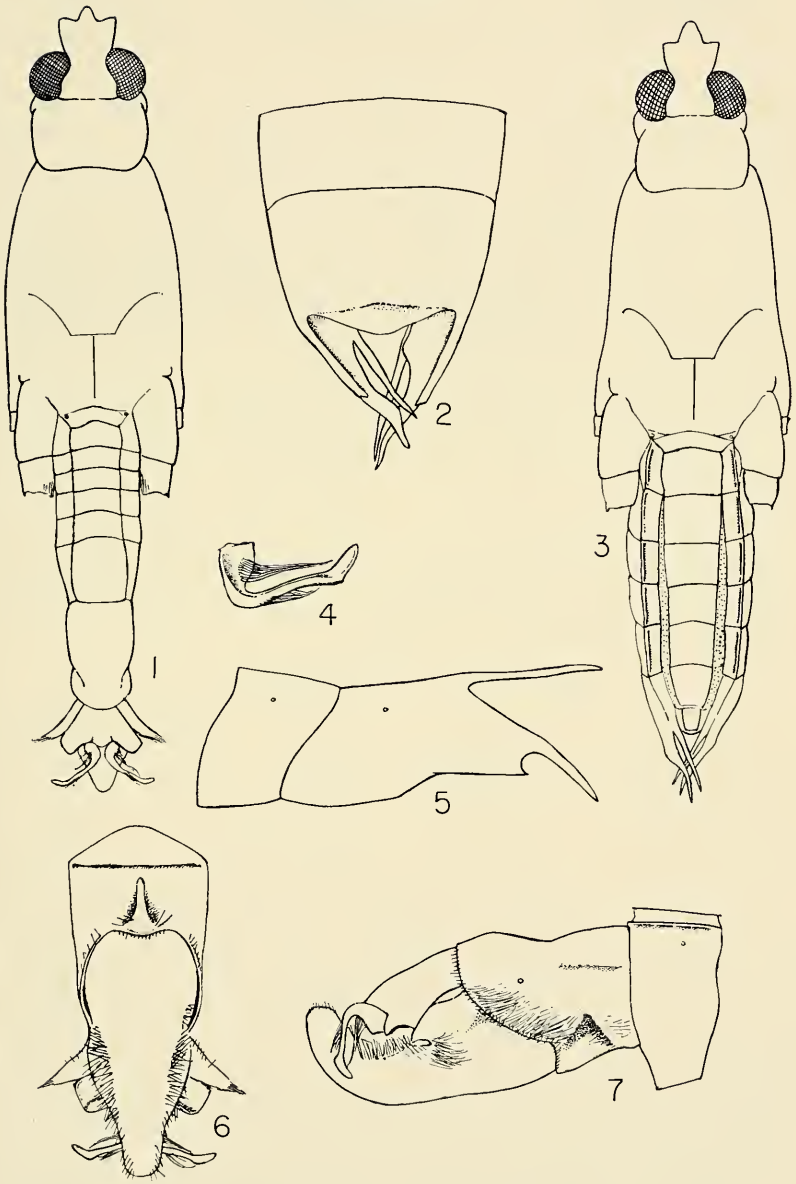
FIG. 4. Enlarged drawing of dorsal view of right paramere. (See fig. 1.)

FIG. 5. Female allotype, left side view of sixth and seventh abdominal segments.

FIG. 6. Male holotype, ventral view of genital segments.

FIG. 7. Male holotype, right side view of genital segments.

PLATE X



Borneo," Forest stream XII 1953, Werner von Hentig leg." Both holotype and allotype are in the Chicago Mus. Nat. Hist.

Distribution: Known only from the type locality.

Ptilomera (*Ptilomera*) *kirkaldyi* n. sp.

Plate XI

We describe below two males from "Ost Borneo" as this species. The female came from "West Borneo" and may prove to be some other species. Therefore, we do not consider it as an allotype.

Size: Male holotype (apterous): Length 19.05 mm.; width of head 2.52 mm.; width of pronotum 2.90 mm.; length of mesonotum 4.33 mm.; greatest width of body across mesoacetabula 4.43 mm. Male paratype (macropterous). Length including wings 17.62 mm.; width of head 2.19 mm.; width across humeri 3.33 mm.; greatest width of body across mesoacetabula 3.88 mm.

Female from West Borneo (apterous): Length 17.14 mm.; width of head 2.19 mm.; width of pronotum 2.19 mm.; length of mesonotum 3.43 mm.; greatest width of body across mesoacetabula 4.10 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::190:43:?:?.
Female: 1st:2nd:3rd:4th::147:33:?:?.

Actual Lengths of Leg Segments

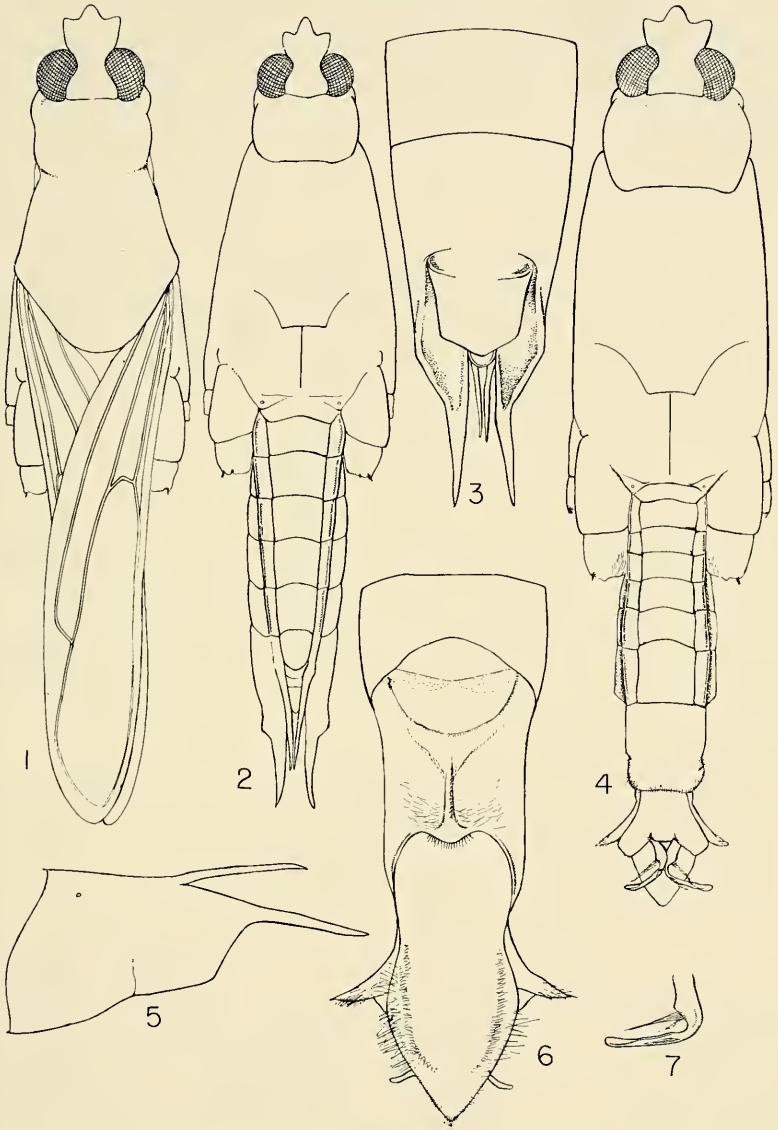
Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male (holotype)	10.00 mm.	8.67 mm.	5.24 mm.	2.00 mm.
Female (W. Borneo)	8.09 mm.	6.76 mm.	4.19 mm.	

Middle leg	Femur	Hind leg	Femur
Male (holotype)	29.1 mm.	Male (holotype)	34.76 mm.
Female (W. Borneo)	22.05 mm.	Female (W. Borneo)	25.71 mm.

Male holotype. Length of pregenital abdominal segments:Genital segments::98:87. Genital segments: Suranal plate with median lobe short, plainly surpassed caudally by the broad lateral lobes. Pygofer, as seen from below conspicuously broad beyond its middle, the sides converging to a dorsally directed point. In side view the pygofer has a slight transverse constriction. The paramere shaped as shown on Plate XI, fig. 7. Venter of first genital segment with a median longitudinal keel.

Female. This unattached female from West Borneo is unlike that of any other Borneo species so we tentatively place it here. Length of thorax:Abdomen::132:184. Seventh abdominal tergite

PLATE XI



Ptilomera (*Ptilomera*) *kirkaldyi* n. sp.

FIG. 1. Male macropterous paratype from Borneo, Ost.

FIG. 2. Apterous female from Nowong, W. Borneo of *P. kirkaldyi* (?).

FIG. 3. Abdominal venter of apterous female from Nowong, W. Borneo of *P. kirkaldyi* (?).

FIG. 4. Holotype apterous male from Borneo, Ost.

FIG. 5. Apterous female from Nowong, W. Borneo. Side view of sixth and seventh abdominal segments of *P. kirkaldyi* (?).

FIG. 6. Venter of genital segments of male holotype.

FIG. 7. Exposed portion of shaft and arm of left paramere of holotype.

a little shorter than the sixth. Connexival spine long, arising from end of connexivum. Dorsolateral lobe of seventh abdominal segment long, spine like for its entire length as seen laterally. Ventrolateral lobe absent or but faintly indicated. Sides of the vertically directed distal lobe of the seventh abdominal sternite straight and nearly parallel.

Comparative notes: The closest relatives of this species are from other species from Borneo.

Types: Holotype apterous male and a paratype macropterous male are from East Borneo. They are in the K. U. Kirkaldy Collection. The female we tentatively assign to this species bears the label, "Mowong, W. Borneo F. Muir, Sept. 1907" and is in the California Academy of Sciences. It is not a type.

Distribution: Known only from above.

Ptilomera (*Ptilomera*) *gressitti* n. sp.

Plate XII

Size: Male holotype (apterous): Length 17.61 mm.; width of head 2.45 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.66 mm.; greatest width of body across mesoacetabula 4.19 mm.

Female paratype (apterous). Length 17.38 mm.; width of head 2.21 mm.; width of pronotum 2.43 mm.; length of mesonotum 3.81 mm.; greatest width of body across mesoacetabula 4.38 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.
Male holotype: 1st:2nd:3rd:4th::173:41: ?: ?.
Male paratype: 1st:2nd:3rd:4th::162:40:50:34.
Female paratype: 1st:2nd:3rd:4th::158:37:48:28+.

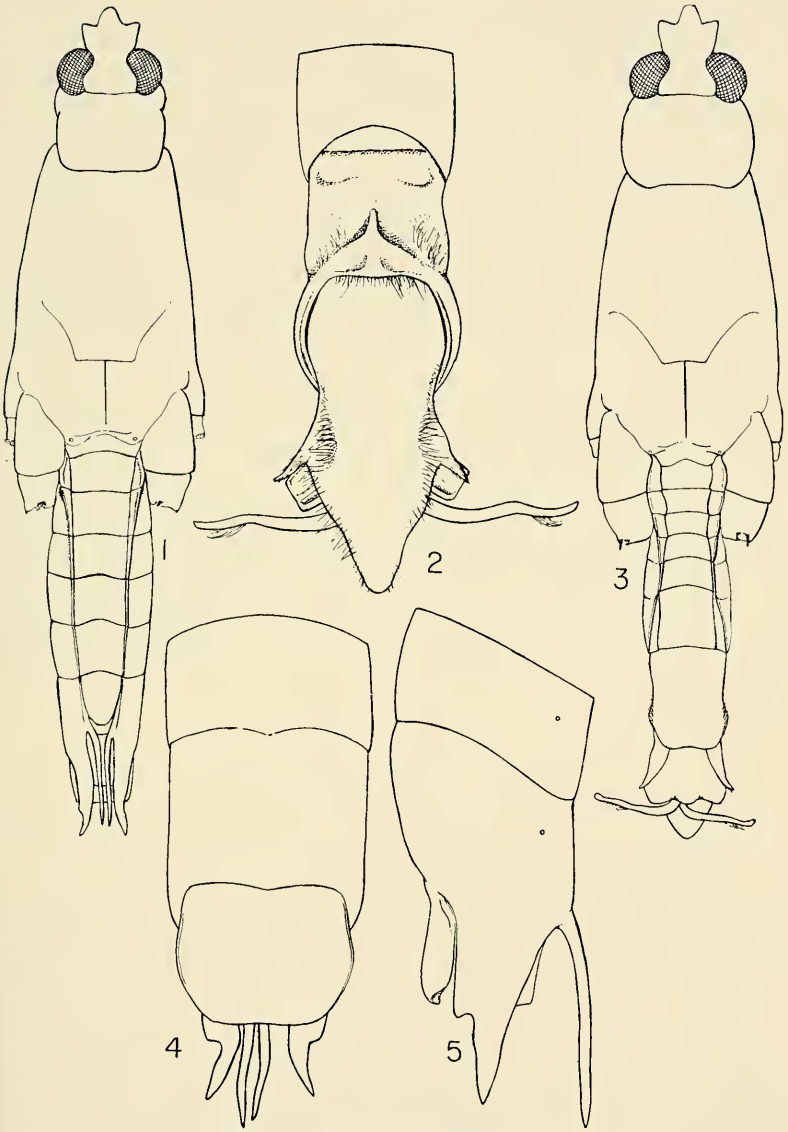
Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male holotype	9.52 mm.	7.81 mm.	4.86 mm.	2.00 mm.
Female paratype	6.24 mm.	7.24 mm.	4.47 mm.	1.76 mm.

Middle leg	Femur	Hind leg	Femur
Male holotype	26.43 mm.	Male holotype	30.95 mm.
Female paratype	22.85 mm.	Female paratype	25.00 mm.

Male. Length of pregenital abdominal segments:Genital segments::87:72. Genital segments: Median lobe of suranal plate small; the short broad lateral wings only slightly surpassing median lobe, their rear margin not longer than the width of their tips. Pygofer as seen from below unusually broad beyond its lateral pro-

PLATE XII



Ptilomera (*Ptilomera*) *gressitti* n. sp.

FIG. 1. Female, dorsal view.

FIG. 2. Male, ventral view of genital segments. Note the long parameres and the unusual width of pygofer at the caudal base of the lateral projections.

FIG. 3. Male, dorsal view.

FIG. 4. Female, ventral view of sixth and seventh abdominal segments. Note the very large median caudal lobe of seventh ventrite.

FIG. 5. Female, side view of above. Note that the median caudal lobe is not turned dorsad as it is in most species.

jections which are slender, pointed and only slightly surpassing laterally the broad short lateral wings of suranal plate. Distal portion of pygofer with sides converging, its tip bluntly rounded. Paramere long, shaft and arm inseparable, as shown on Plate XII fig. 2.

Female. The length of thorax:Abdomen::142:172. Seventh abdominal tergite as long as the sixth. Connexival spine moderately long and arising from end of connexivum. In side view the species is unlike any other species. At first glance the dorsolateral lobe appears to have a notch on its lower margin and no ventrolateral lobe. However, the lower lobe beyond the notch is the ventrolateral lobe and therefore in the key it runs out to couplet 36. The distal lobe of seventh abdominal sternite is unusually large and not turned vertically.

Comparative notes: The female is unique, and its closest relative may be *P. nunikanensis.* The male, however, appears to be related to *P. kirkaldyi* and *P. nunikanensis.*

Types: Described from an apterous series containing 3 ♂ ♂, and 2 ♀ ♀ that bear the following labels: "British N. Borneo, West Coast Residency, Ranau 8 mi. N. Paring Hot Springs, 500m. Oct. 8-11, 1958" "T. C. Maa collector" Holotype, allotype and one male paratype are in the Bernice P. Bishop Museum, Honolulu, Hawaii, and one pair of paratypes are in the K. U. collection.

Distribution: Known only from the type locality.

Ptilomera (*Ptilomera*) *hylactor* Breddin

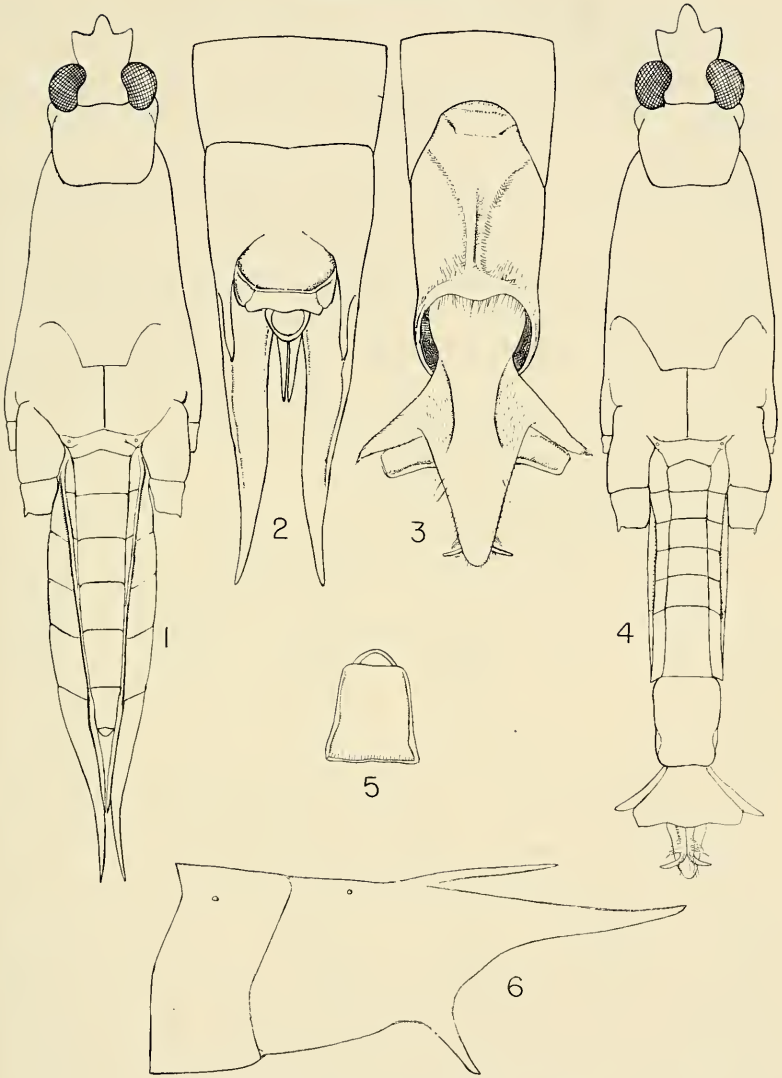
Plate XIII

1903. *Ptilomera hylactor* Breddin, Societas Entomologica 17(19):148. (Described from annam. ♂ and ♀).
1927. *Ptilomera hylactor,* Esaki, Eos, Rev. Esp. Ent. 3(3):259.
1933. *Ptilomera hylactor,* Hoffmann, Lingnan Sci. Jour. 12 Suppl. p. 247.
1933. *Ptilomera hylactor,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 419.
1941. *Ptilomera hylactor,* Hoffmann, Lingnan Sci. Jour. 20(1):35.
1960. *Ptilomera hylactor,* Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 539, fig. 621.

Of the ten species described by Breddin, he gave one or more figures for six of them. He gave no figure for *P. hylactor.* However, his description is adequate to recognize this striking species. He said it was the largest species known to him but it would have been more accurate to say it is the longest and most slender species.

For the redescription of this species we have before us three specimens from Breddin's collection that bear the label, "Annam Phuc-Son Nov.-Dez. H. Fruhstorfer," one male without genitalia, one female and one nymph. These now bear the red label "Typus" "det.

PLATE XIII



Ptilomera (*Ptilomera*) *hylactor* Breddin

FIG. 1. Female from type series, dorsal view.

FIG. 2. Ventral view of sixth and seventh abdominal segments of above female.

FIG. 3. Male from type series, ventral view of genital segments. Note the broad complete median keel on first genital segment and remarkable shape of the venter of the pygofer.

FIG. 4. Male from type series, dorsal view.

FIG. 5. Female, rear view of middle lobe of seventh abdominal ventrite.

FIG. 6. Female, sixth and seventh abdominal segments as seen from left side.

by Lundblad." We find in our Torre-Bueno Collection a pair with the same identical label as above and these enable us to give the following information:

Size: Breddin gave the length 18.5—19.5 mm. Hind femur and trochantur ♂ 32.5 mm. ♀ 26.5 mm.; while our Torre-Bueno pair are as follows:

Male (apterous): Length 18.1 mm.; width of head 2.17 mm.; width of prothorax 2.24 mm.; length of mesonotum 3.57 mm.; greatest width of body across mesoacetabula 3.64 mm.

Female (apterous): Length 18.57 mm.; width of head 2.12 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.71 mm.; greatest width of body across mesoacetabula 4.00 mm.

Color: Quite typical for the genus. However, the four adults available to us have the abdominal tergites black.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::158:40:?:?.

Female: 1st:2nd:3rd:4th::162:33:?:?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	8.81 mm.	7.23 mm.	4.38 mm.	1.85 mm.
Female	8.19 mm.	6.57 mm.	4.33 mm.	1.91 mm.

Middle leg	Femur	Hind leg	Femur
Male	24.52 mm.	Male	29.05 mm.
Female	21.9 mm.	Female	25.00 mm.

Male. Length of pregenital segments:Genital segments::102:85. Genital segments: Suranal plate with median lobe very short but moderately broad. Lateral wings of suranal plate short, moderately broad, their front and rear margins not parallel and not surpassing median lobe. Venter of pygofer with basal two thirds narrow, resembling a broad keel, sides above the keel concave to a position beyond the lateral projections of pygofer. As seen from below pygofer not conspicuously broad beyond its middle. Apex of pygofer bluntly rounded. Venter of first genital segment with a well developed keel. In dorsal view first genital is plainly longer than seventh tergite or than suranal plate.

Female. Length of thorax:Abdomen::142:207. Seventh abdominal tergite as long as sixth. Connexival spine moderately long, arising from the end of the connexivum. Incission between dorsolateral and ventrolateral lobes broad and shallow. Both lobes long and spine-like. Dorsolateral lobe of seventh abdominal segment long, stout and straight, its upper margin from base of connexival

spine to its tip nearly twice as long as connexival margin of seventh abdominal segment. Distal lobe of the seventh sternite rather long and narrow, turned dorsally and embraced by lateral lobes.

Comparative notes: This species stands quite alone, but runs out to couplet 13 in the key to males, and to couplet 47 in key to females.

Types: An apterous male without the genital segments, and an apterous female and one nymph, all bearing the label "Annam Phuc-Son Nov. Dez. H. Fruhstorfer." All types are in Deutsches Entomologisches Institut, Berlin.

Distribution: Known only from the type series, a pair of which we found undetermined in our Kirkaldy Collection at K. U., and 1 ♂ bearing the label "Haut Mekong Pau Lan 13 V. 1918. R. V. de Salvaza" (Brit. Mus.).

Ptilomera (*Ptilomera*) *breddini* n. sp.

Plate XIV

Size: Male paratype (apterous): Length 15.62 mm.; width of head 2.1 mm.; width of pronotum 2.36 mm.; length of mesonotum 3.14 mm.; greatest width of body across mesoacetabula 3.48 mm.

Female paratype (apterous): Length 15.00 mm.; width of head 2.1 mm.; width of pronotum 2.14 mm.; length of mesonotum 2.90 mm.; greatest width of body across mesoacetabula 3.86 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::142:38:?:?.

Female: 1st:2nd:3rd:4th::128:28:?:?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	7.61 mm.	6.67 mm.	3.71 mm.	1.43 mm.
Female	6.67 mm.	5.81 mm.	3.81 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male	20.48 mm.	Male	22.62 mm.
Female	18.57 mm.	Female	19.52 mm.

Male. Length of pregenital abdominal segments:Genital segments::91:81. Genital segments: Suranal plate with median lobe broader than the lateral wings which are long, surpassing caudally the median lobe and have their front and rear margins nearly parallel. Pygofer with its dorsolateral projections short and rather slender. Pygofer as seen from below not conspicuously broad beyond its middle and appearing rather elongate, its venter appear-

Ptilomera (*Ptilomera*) *breddini* n. sp.

FIG. 1. Female allotype, dorsal view.

FIG. 2. Male holotype, ventral view of genital segments.

FIG. 3. Male holotype, dorsal view.

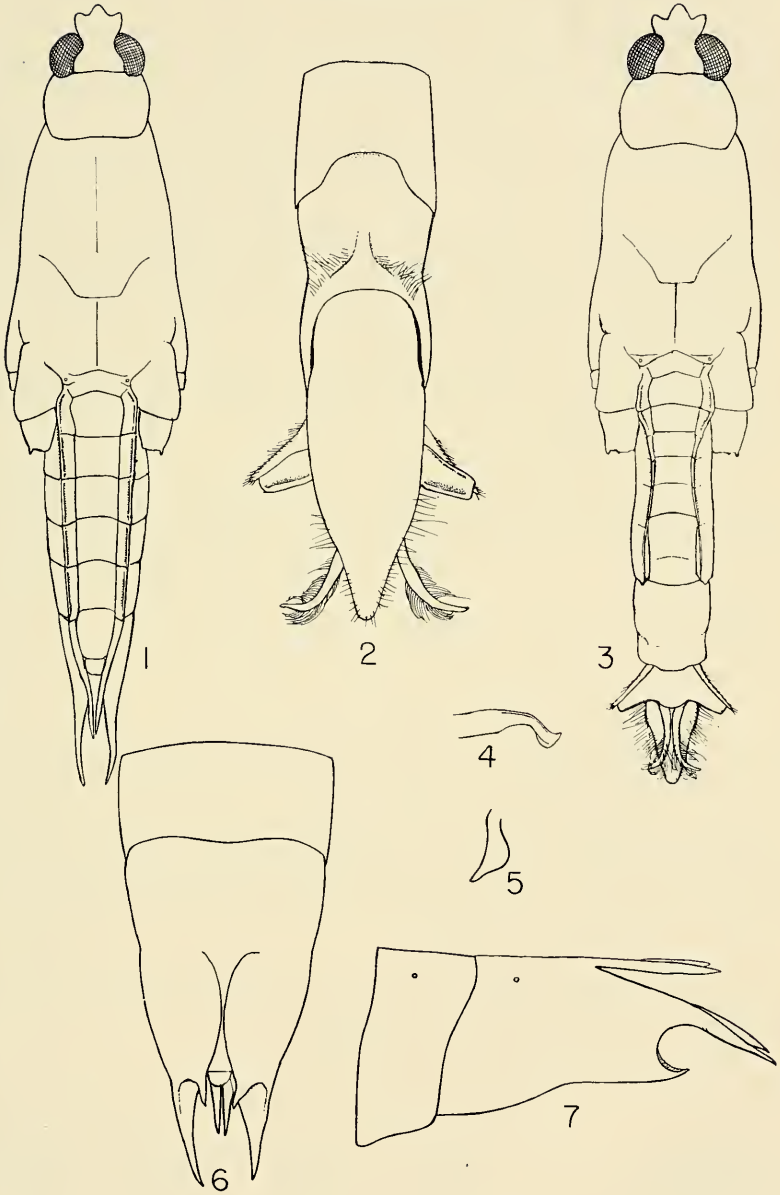
FIG. 4. Male holotype, side view of left paramere.

FIG. 5. Male holotype, rear view of arm of left paramere.

FIG. 6. Female allotype, ventral view of sixth and seventh abdominal segments.

FIG. 7. Female allotype, left side view of sixth and seventh abdominal segments.

PLATE XIV



ing slender, its tip pointed. Paramere with its shaft longer than its arm. The arm as seen from the rear, with a ventral bulge or keel as shown of Plate XIV figs. 4, 5.

Female. Length of thorax:Abdomen::116:160. Seventh abdominal tergite about as long as sixth. Connexival spine moderately long and arising from end of seventh connexivum. Seventh abdominal segment with dorsolateral and ventrolateral lobes separarated by a deep incission; dorsolateral lobe rather slender, only moderately long, its upper margin from base of connexival spine to its tip much less than twice as long as connexival margin of seventh abdominal segment. Distal lobe of seventh abdominal sternite of usual size and embraced by the lateral lobes, its sides straight and nearly parallel and directed vertically.

Comparative notes: Nearest relative is *P. papuensis* n. sp. which runs out with it to couplet 16 of the key to males and to couplet 49 in the key to females.

Types: Male holotype, allotype and 2 males and 1 female paratypes bearing the label "N. Guinea S. E. Haveri, Loria VII, XI-93." and one male "Milne Bay, N. Guinea" one female "N. Guinea, S. E. Paunemu riv. Loria IX-XII 92". Types are in the Kirkaldy Collection at K. U.

Distribution: Known only by the type localities.

Ptilomera (*Ptilomera*) *papuensis* n. sp.

Plate XV

Size: Male paratype (apterous): Length 15.00 mm.; width of head 2.02 mm.; width of pronotum 2.42 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.67 mm. Female paratype (apterous). Length 14.52 mm.; width of head 1.95 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.81 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::138:35:49:31.
Female: 1st:2nd:3rd:4th::125:29:40:28.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male paratype	7.61 mm.	6.67 mm.	3.71 mm.	1.43 mm.
Female paratype	6.67 mm.	5.81 mm.	3.81 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male paratype	20.48 mm.	Male paratype	22.62 mm.
Female paratype	18.57 mm.	Female paratype	19.52 mm.

Male. Length of pregenital abdominal segments:Genital segments::80:118. Genital segments: Suranal plate with median lobe not large, not wider than width of lateral wings which are long, surpassing caudally the median lobe and have their front and rear margins nearly parallel. Pygofer with its dorsolateral projections short and rather slender. Pygofer as seen from below not conspicuously broad beyond its middle and rather elongate, its venter appearing slender, its tip pointed. Paramere with shaft longer than its arm. See Plate XV fig. 4.

Female. Length of thorax:Abdomen::135:163. Seventh tergite slightly shorter than sixth. Connexival spine moderately long and arising from end of seventh connexivum. Seventh abdominal segment with dorsolateral and ventrolateral lobes separated by a deep incission; dorsolateral lobe stout, only moderately long, more or less spine-like, its upper margin from base of connexival spine to its tip much less than twice as long as connexival margin of seventh abdominal segment. Distal lobe of seventh abdominal sternite of usual size.

Comparative notes: Its nearest relative is *P. breddini* n. sp., which runs out with it to couplet 16 of the key to males and to couplet 49 in the key to females.

Types: Male holotype, allotype and 5 males and 5 female paratypes, all apterous, bear the label "Mt. Lamington N. E. Papua 1300-1500 ft. C. T. McNamara." One pair of paratypes are in the K. U. collection. All others are in S. Australian Museum.

Distribution: Besides the above types there are three males and one female which bear the label "Finsch Haven, New Guinea L. Wagner." These are very pale specimens and appear teneral. The males appear to be this species but the female has the ventrolateral lobe of the seventh segment broadly truncate at tip but may represent the same kind of variation that appears to occur in *P. harpyia* Schmidt.

Ptilomera (*Ptilomera*) *papuensis* n. sp.

Fig. 1. Female from N. E. Papua, dorsal view.

Fig. 2. Male from above place, ventral view of genital segments.

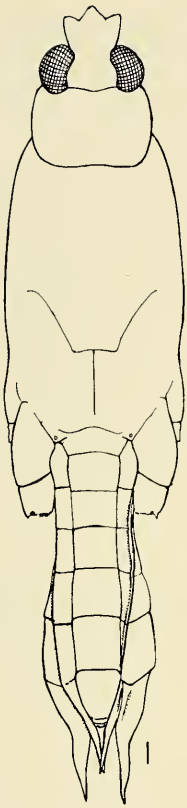
Fig. 3. Male from above place, dorsal view. Note the long parallel sided lateral wings of suranal plate.

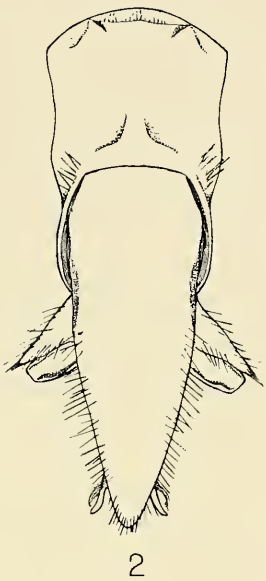
Fig. 4. Male. Left paramere as seen from the side.

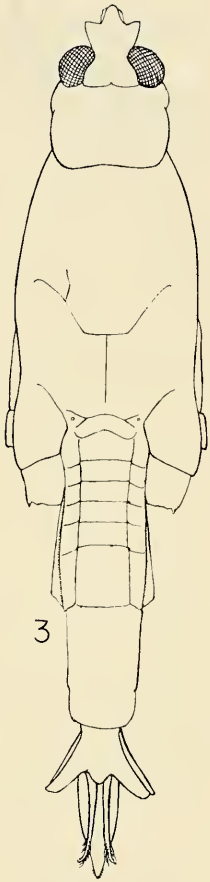
Fig. 5. Same female as in figure 1, ventral view of sixth and seventh abdominal segments.

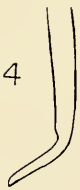
Fig. 6. Female, side view of sixth and seventh abdominal segments.

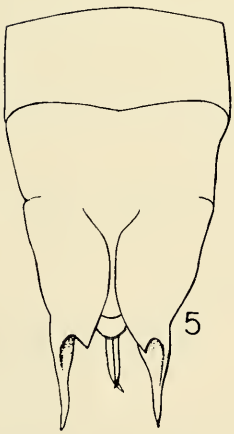
PLATE XV

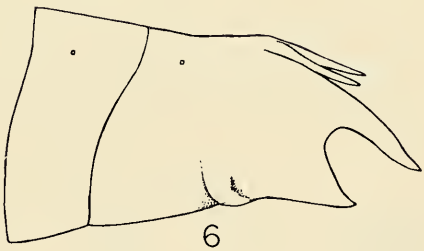












Ptilomera (*Ptilomera*) *aëllo aëllo* Breddin

Plate XVI, figs. 3, 8 and 9

1906. *Ptilomera aëllo* Breddin, Societas Entomologica, 21(2):9. (Described from 3 apterous ♀♀, 1 nymph from "Timmena, Nieuw Guinea Expeditie 1903").

1958. *Ptilomera aëllo* Hungerford and Matsuda, Bull. Brooklyn Ent. Soc. 53(3):69.

1960. *Ptilomera aëllo* Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 539.

This species from New Guinea has been overlooked by other writers for fifty years. It was published in an obscure journal which claimed to be the "Organ of the International Entomological Society" and we found it in R. 9 of the bound volumes of Kirkaldy's library of separates in the University of Kansas. In his description Breddin wrote that this species is broader and shorter than the other species known to him, the abdomen shorter in relation to the thorax. His color description is not specific. He gave no illustration but said that the contour of the side plate of the seventh addominal segment was nearest to that of *P. pamphagus* Breddin. We therefore give the following redescription and figures of his types:

Size: Breddin gave the length as 14.00 mm. including the connexival spines 14.5 mm. We here give the measurements of the largest of the three apterous female cotypes. Length 14.00 mm.; width of head 2.05 mm.; width of pronotum 2.19 mm.; length of mesonotum 3.09 mm.; greatest width of body across the mesoacetabula 4.33 mm.

Color: Typical for the genus. The ground color and black markings subject to the same variations that occur in most other species. For example, one cotype has four distinct black dots on the vertex, as described by Breddin, a second has front and rear dots on each side connected by an embrowned line, and the third cotype has the embrowned connecting line nearly black so that the vertex has two converging lines on the vertex instead of four dots.

Structural characteristics: Relative lengths of antennal segments. 1st:2nd:3rd:4th::125:33:46:31.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female type	6.9 mm.	5.9 mm	3.81 mm.	1.38 mm.
Middle leg	Femur	Hind leg		Femur
Female type	19.14 mm.	Female type		21.19 mm.

Female. Length of the thorax:Abdomen::114:132 in one cotype and ::120:135 in another. Thus this is not a character that would

separate this species from others as Breddin thought. Since the male of this species is unknown, we can only give the characters of the seventh abdominal segment of the female. Seventh tergite a little shorter than sixth. Connexival spines long, arising from the curved edge of the connexivum. Dorsolateral and ventrolateral lobes short, separated by a moderately narrow and deep incission; dorsal margin from base of connexival spine to its tip nearly straight or slightly concave and shorter than the connexival spine.

Comparative notes: This is one of species in which the incission between dorsolateral and ventrolateral lobes is relatively small in the female. Yet this species can be recognized from the couplet 46 in the key to female.

Types: Three females from "Nieuw Guinea Expeditie Timmema 6-7 apr." In Deutsches Entomologisches Institut in Berlin.

Distribution: Known only from the type locality.

Ptilomera (*Ptilomera*) *aëllo cheesmanae* n. subsp.

Plate XVI, figs. 1, 2, 4, 5, 6, 7, 10

We have three species from New Guinea, none of which possesses females like the type of *P. aëllo* Breddin, but one is certainly close. Therefore we are placing it as a subspecies.

Size: Male holotype (apterous): Length 16.67 mm.; width across head 2.48 mm.; width of pronotum 7.71 mm.; length of mesonotum 8.81 mm.; greatest width of body across mesoacetabula 4.43 mm.

Female allotype (apterous): Length 15.24 mm.; width across head 2.24 mm.; width of pronotum 2.38 mm.; length of mesonotum 3.14 mm.; greatest width of body across mesoacetabula 4.57 mm.

Color: Typical for the genus. In most of the specimens the vertex has a black line along the inner margin of the eye that joins the front end of each of the two converging lines.

Structural characteristics: Relative lengths of antennal segments:

Male: 1st:2nd:3rd:4th::167:44:54:36.

Female: 1st:2nd:3rd:4th::135:35:47:31.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	8.95 mm.	6.76 mm.	5.14 mm.	1.71 mm.
Female	7.15 mm.	6.29 mm.	3.00 mm.	1.48 mm.

Middle leg	Femur	Hind leg	Femur
Male	25.90 mm.	Male	30.71 mm.
Female	20.48 mm.	Female	22.48 mm.

PLATE XVI

Ptilomera (*Ptilomera*) *aëllo aëllo* Breddin

FIG. 3. Female cotype, dorsal view.

FIG. 8. Female cotype, ventral view of sixth and seventh abdominal segments.

FIG. 9. Female cotype, lateral view of sixth and seventh abdominal segments.

Ptilomera (*Ptilomera*) *aëllo cheesmanae* n. subsp.

FIG. 1. Female, dorsal view.

FIG. 2. Female, ventral view of sixth and seventh abdominal segments.

FIG. 4. Male, dorsal view.

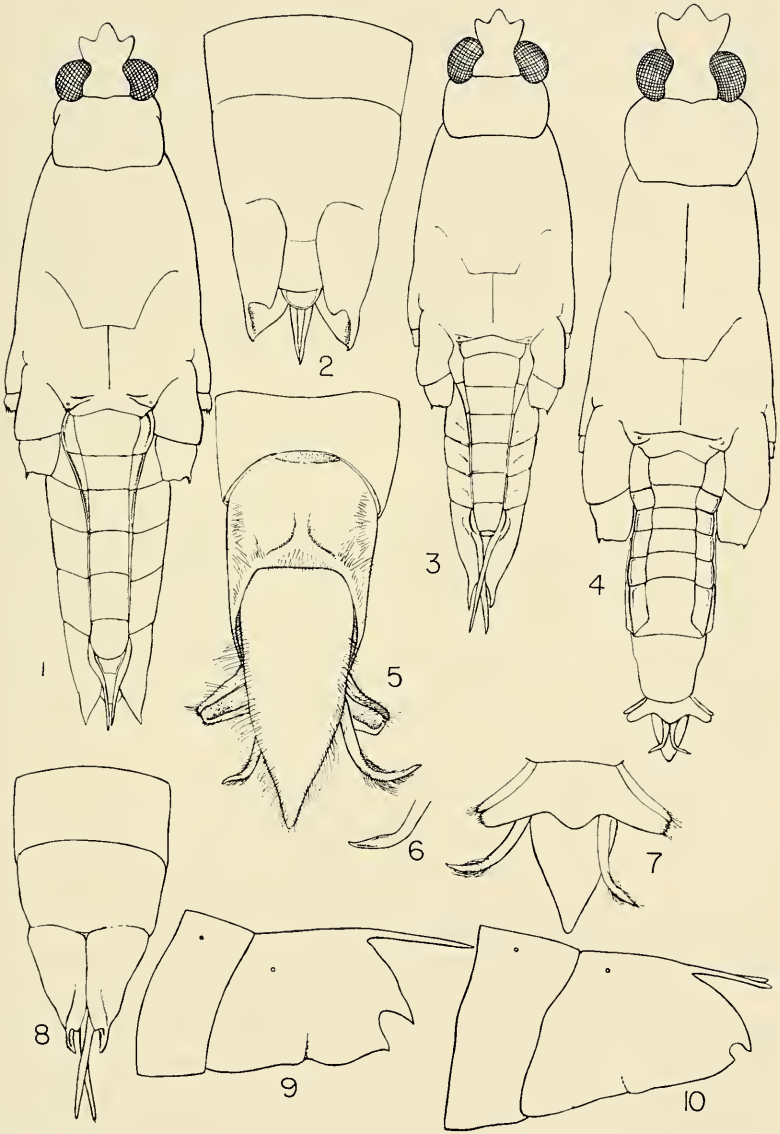
FIG. 5. Male, ventral view of genital segments.

FIG. 6. Male, left paramere.

FIG. 7. Male, dorsal view of second genital segment.

FIG. 10. Female, lateral view of sixth and seventh abdominal segments.

PLATE XVI



Male. Length of pregenital abdominal segments:Genital segments::85:62. Genital segments: Suranal plate with median lobe not large. Lateral wings of suranal plate with front and rear margins nearly parallel, not surpassing median lobe caudally. Lateral wings rather long, rear margins nearly twice as long as their width at their tips. Pygofer with short dorsolateral projections; Apex of pygofer pointed; Pygofer as seen from below not conspicuously broad beyond its middle; paramere as shown on Plate XVI figs. 6, 7.

Female. Length of thorax:Abdomen::130:152. Seventh tergite considerably shorter than sixth. Connexival spines not as long as in the true *P. aëllo.* The connexival ridge convexly curved laterally before forming the base of connexival spine. Dorsolateral and ventrolateral lobes short, separated by a moderately narrow incission; dorsolateral lobe turned obliquely down, its dorsal margin from base of connexival spine to its tip convexly curved and longer than connexival spine.

Comparative notes: The key will separate the female from that of the typical *P. aello,* and the male in couplet 17 from *P. oribasus* Breddin.

Types: Described from apterous male holotype, apterous female allotype and two male and two female paratypes from "Dutch New Guinea, Cyclops Mts. Mt. Lina 3500 ft. III 1936 L. E. Cheesman" and 3 male and 2 female paratypes from "Dutch New Guinea Cyclops Mts. Sabron. 930 ft. IV 1936 L. E. Cheesman. All are apterous. The type series is in the British Museum. 1 male and 1 female are in K. U. collection.

Distribution: Known only for the type localities.

Ptilomera (*Ptilomera*) *tigrina* Uhler

Plate XVII, figs. 1, 2, 4

1860. *Ptilomera tigrina* Uhler, Pro. Acad. Nat. Sci. Philadelphia June 1860: 230. (Described from Hong Kong).

1866. *Ptilomera tigrina,* Mayr, Novara-Exped. Zool. Theil. Bd. II Abth. 1:177. (Gave this as synonym of *P. laticaudata* (Hardw.) in error).

1904. *Ptilomera tigrina,* Distant, Faun. Brit. Ind. Rhynch. II:185. (Gave this as synonym of *P. laticaudata* (Hardw.) in error).

1927. *Ptilomera tigrina,* Esaki, Eos, Rev. Esp. Ent. 3(3):259. (Listed).

1933. *Ptilomera tigrina,* Wu, Lingnan Sci. Jour. 12 Suppl:209. (Listed).

1933. *Ptilomera tigrina,* Hoffmann, Lingnan Sci. Jour. 12 Suppl.:247. (Listed).

1933. *Ptilomera tigrina,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 418. (He did not see this species).

1935. *Ptilomera tigrina,* Wu, Ins. Sinen. 2:543. (Catalogue).

1941. *Ptilomera tigrina,* Hoffmann, Lingnan Sci. Jour. 20(1):35. (Catalogue).

For more than one hundred years this species has remained unrecognized although three female types have been in the U. S. National Museum in Washington D. C. during all this time.

Redescription of these female types:

Size: Female paratype (apterous). Length 16.43 mm.; width of head 2.05 mm.; width of pronotum 2.12 mm.; length of mesonotum 3.29 mm.; greatest width of body across mesoacetabula 3.71 mm.

Color: Color and pattern typical for the genus. These types have the abdominal tergites mostly of the ground color with the black markings confined to the anterior and lateral margins of each tergite.

Structural characteristics: Antennae are missing.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female (paratype)	7.00 mm.	6.05 mm.	3.67 mm.	1.48 mm.

Middle leg	Femur	Hind leg	Femur
Female (paratype)	20.14 mm.	Female (paratype)	22.14 mm.

Males are unknown but we suspect that when they are found *P. harpyia* Schmidt will be a synonym of this species.

Female. Length of thorax:Abdomen::132:172. Seventh abdominal tergite shorter than sixth tergite (82.35:100). Connexival spine of moderate length, arising far beyond the seventh tergite, of moderate length but not reaching the tip of the dorsolateral lobe. Ventrolateral lobe broad and truncate at tip. Distal lobe of seventh abdominal sternite hidden by the broad ventrolateral lobes and directed dorsad. Dorsolateral lobe of seventh abdominal segment moderately long and spine-like, its upper margin from base of connexival spine to its tip much less than twice as long as connexival margin of seventh abdominal segment. Incission between the dorsolateral and ventrolateral lobes of seventh abdominal segment not as deep as broad. In side view ventrolateral lobe of seventh abdominal segment longer than the venter of seventh abdominal segment before it.

Types: Three females from Hong Kong, China are in the U. S. National Museum.

Comparative notes: Every close to, if not identical with, *P. harpyia* Schmidt from Cambodia which may prove to be a synonym.

Distribution: Known only from the type locality. *If P. harpyia* proves to be a synonym of this species, it will extend its distribution far to the south and westward.

Ptilomera (*Ptilomera*) *tigrina* Uhler

FIG. 1. Female cotype, dorsal view.

FIG. 2. Female cotype, ventral view of sixth and seventh abdominal segments. Note the truncate tip of ventrolateral lobe and that the base of this lobe is broad, its basal margin turned medially, its inner margin nearly meeting opposite lobe.

FIG. 3. Male of *P. harpyia* Schmidt from Loas, Tonkin.

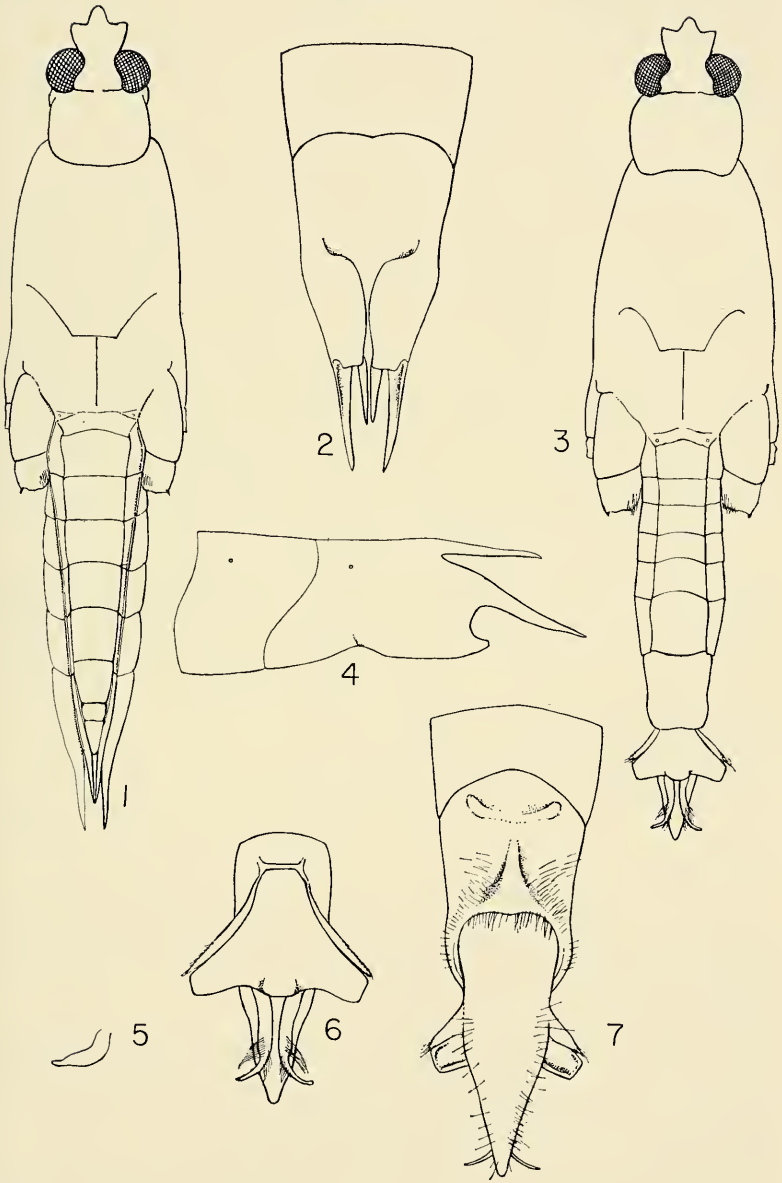
FIG. 4. Female cotype, ventral view of sixth and seventh abdominal segments.

FIG. 5. Male of *P. harpyia* Schmidt from Laos, Tonkin. Arm of left paramere seen from rear view.

FIG. 6. Male of *P. harpyia* Schmidt from Laos, Tonkin. Dorsal view of second genital segment.

FIG. 7. Male of above, ventral view of genital segments.

PLATE XVII



Ptilomera (*Ptilomera*) *harpyia* Schmidt

Plate XVII, figs. 3, 5, 6, 7, and Plate XVIII

1926. *Ptilomera harpyia* Schmidt, Ent. Mitt. 15(1):65. (Described female from "Cambodja").
1927. *Ptilomera harpyia*, Esaki, Eos, Rev. Esp. Ent. 3(3):259-260.
1933. *Ptilomera harpyia*, Hoffmann, Lingnan Sci. Jour. 12 Suppl. 247.
1933. *Ptilomera harpyia*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 373, 419-421.
1941. *Ptilomera harpyia*, Hoffmann, Lingnan Sci. Jour. 20:34.
1960. *Ptilomera harpyia*, Matsuda, Univ. Kansas Sci. Bull. 41(2):267.

As in other Schmidt types the seventh abdominal segment is mounted on a slide. If this had not been done the type could have been described and illustrated more satisfactorily. We have no specimens from Cambodia. Fortunately we have found in our Torre-Bueno Collection, "Laos, Tonkin." The females are very near the cotypes of *P. trigrina* Uhler from Hong Kong, China, and the type of *P. harpyia* Schmidt from Cambodia. However, these females from Tonkin are more like the *P. harpyia* Schmidt type, and we are therefore labeling them *P. harpyia* Schmidt. Whether the latter is a synonym of *P. tigrina* or not cannot be determined until we see males that are taken with females of *P. tigrina.*

Size: Schmidt gave the body length of the apterous female type "14.00 mm." *; greatest width 4.00 mm.; length of hind femur 22.00 mm." We add the following: Width of head 2.05 mm.; width of pronotum 2.10 mm.; length of mesonotum 3.43 mm.; greatest width of body across mesoacetabula 3.67 mm. Measurements of an apterous pair from "Laos, Tonkin":

Male. Length 17.14 mm.; width of head 2.24 mm.; width of pronotum 2.33 mm.; length of mesonotum 3.71 mm.; greatest width of body across mesoacetabula 3.81 mm. This we have labeled "Neallotype."

Female. Length 17.71 mm.; width of head 2.10 mm.; width of pronotum 2.14 mm.; length of mesonotum 3.62 mm.; greatest width of body across mesoacetabula 3.86 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Female type: 1st:2nd:3rd:4th::140:32:41:28.

Male from Laos: 1st:2nd:3rd:4th::162:40: ?: ?.

Female from Laos: 1st:2nd:3rd:4th::142:32:42:27.

* By adding length of the body of the type and slide mount we get 16.66 mm. instead of 14.00 mm.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female type	6.95 mm.	6.05 mm.	3.81 mm.	1.52 mm.
Male from Laos	8.33 mm.	7.28 mm.		
Female from Laos	7.86 mm.	6.29 mm.	4.10 mm.	1.57 mm.

Middle leg	Femur	Hind leg	Femur
Female type	21.52 mm.	Female type	22.00 mm.
Male from Laos	24.05 mm.	Male from Laos	27.95 mm.
Female from Laos	20.48 mm.	Female from Laos	23.67 mm.

Female. Relative length of the thorax is to that of the abdomen cannot be determined for the female holotype but for a female from Laos it is 137:172. Connexival spine about as long as seventh abdominal tergite and arises at end of seventh connexivum. Both dorsolateral and ventrolateral lobes present. Dorsolateral lobe rather long, more or less spine-like, its upper margin from base of connexival spine to its tip much less than twice as long as connexival margin of seventh abdominal segment. Incission between the dorsolateral and ventrolateral lobes not as deep as broad; dorsolateral lobe broad at base; ventrolateral lobe truncate at tip in types of both *P. tigrina* Uhler and *P. harpyia* Schmidt. However, the latter species varies as shown on Plate XVIII figs. 7, 8, 9.

Male neallotype. Length of pregenital abdominal segments: Genital segments::102:73. Genital segments: Suranal plate with median lobe small, not surpassing lateral wings which are moderately short, their front and rear margins not parallel. Pygofer as seen from below with distal half slender and pointed. Dorsolateral projection of pygofer as seen in dorsal view short and slender. Paramere with shaft longer than arm which turns obliquely laterad as seen from above. In rear view the arm is curved obliquely dorsad, its sides not parallel.

Comparatives notes: This species cannot be placed as a synonym of *P. tigrina* Uhler until the male of the latter is found.

Type: The apterous female type bears the labels "Cambodja" and Schmidt's determination label. They are in the Polish Academy of Sciences, Warsaw, Poland. The apterous male neallotype bears the label "Laos, Tonkin." Four other males and two females that have been compared with the types of *P. tigrina* Uhler and *P. harpyia* Schmidt appear to be the same as the latter.

Distribution: In addition to the types we have seen the following: Laos: "Laos-Tonkin Staudinger and Bank-Haas. 1 female that is like the above. (California Acad. Sci.) "Laos Ban Na Mon. Dec. 12, 1919. R. V. de Salvaza" 1 ♀ (British Mus.)

Ptilomera (*Ptilomera*) *harpyia* Schmidt

FIG. 1. Female from Laos, Tonkin, compared with type. Dorsal view.

FIG. 2. Side view of sixth and seventh abdominal segments of above female.

FIG. 3. Ventral view of sixth and seventh abdominal segments of above female.

FIG. 4. Ventral view of seventh abdominal segment of type drawn from slide mount.

FIG. 5. Female from Chiengriai, Thailand. Side view of seventh abdominal segment. We have a female like this from Laos.

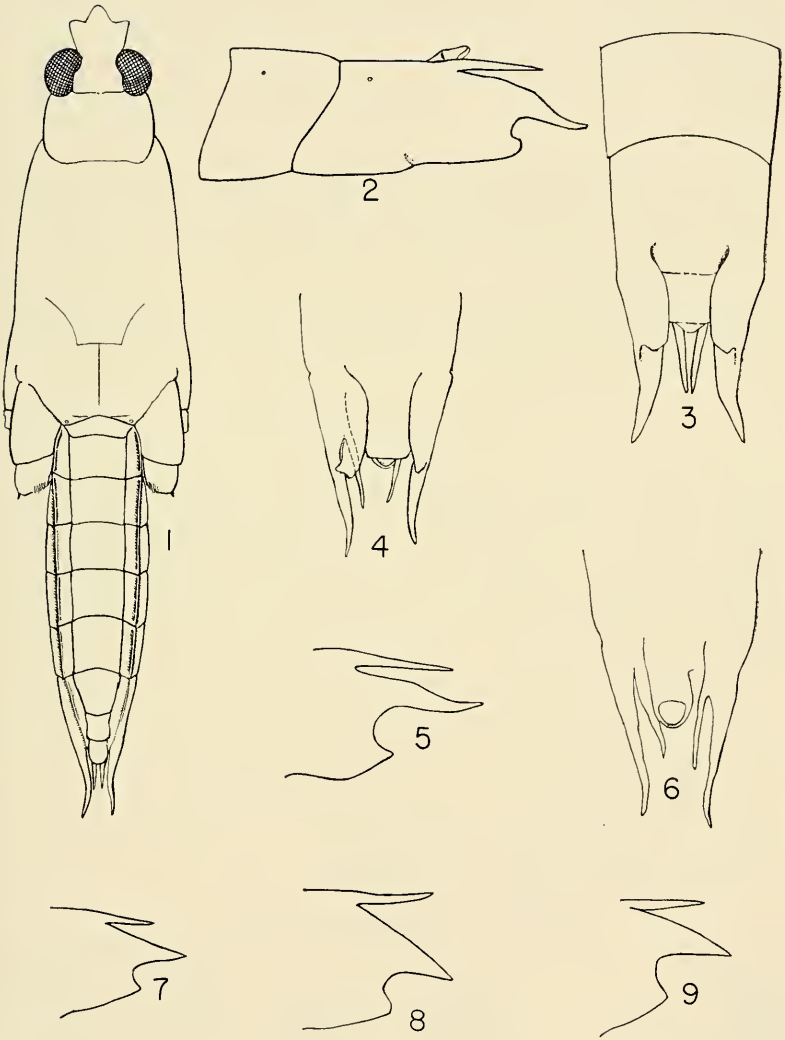
FIG. 6. Female type. Seventh segment of type in dorsal view, drawn from the slide mount.

FIG. 7. Female from Trang, Thailand. Side view of seventh abdominal segment.

FIG. 8. Another female from above place.

FIG. 9. Still another female from Trang, Thailand. Note that only Fig 8 has a truncate end of the ventrolateral lobe as in *P. harpyia* type. Males do not show such variation.

PLATE XVIII



Thailand: "Trang, Thailand, Namtok Ching. Apr. 18, 1952. Mt. str. M. E. Griffith 2 ♂ ♂, 3 ♀ ♀. While the males are undoubtedly *P. harpyia* (see Plate XVII fig. 3), the females vary, only fig. 8 on plate XVIII is near the typical form. (K. U. Col.). "Chiengmai, Thailand. Doi Sutep. Mt. Stream Mra. 26, 1952, M. E. Griffith" 2 ♀ ♀, 3 nymphs. (K. U. Col.) "Thailand 957d. Chiengmai Prov. Puang Rapila D. C. Thurman" 2 ♀ ♀. (K. U. Col.)

Burma: "Myitkyina, Burma Nov. 30, 1945, B. McDermett" 1 ♀, 2 nymphs. (K. U. Col.); "Tingkawk, Burma, May 25, 1944, L. C. Kuitert" 2 ♂ ♂, 2 ♀ ♀.

Malaya: "Gunong Pulai Johore Feb. 10, 1961, C. H. Fernando" 1 ♂, 1 ♀; same place "Feb. 21, 1961." 2 ♂ ♂ (K. U. Col.); "Gunong Pulai, Stream June 1960, C. H. Fernando." 2 ♀ ♀ (K. U. Col.); "Malay Panin. Selangor" 2 apterous and 1 macropterous ♂ ♂. (British Museum).

Philippines: "C. N. H. Mus. Philippine Zool. Exp. 1946-47. F. C. Werner. leg" 1 ♂. (Chicago N. H. Mus.).

Ptilomera harpyia ceramensis n. subsp.

Plate XIX

Size: Male holotype (apterous). Length 14.28 mm.; width of head 2.00 mm.; width of pronotum 2.14 mm.; length of mesonotum 2.90 mm.; greatest width of body across mesoacetabula 3.00 mm.

Female allotype (apterous): Length 13.90 mm.; width of head 1.95 mm.; width of pronotum 2.00 mm.; length of mesonotum 2.86 mm.; greatest width of body across mesoacetabula 3.38 mm.

Color: These two specimens have more of the ground color and smaller black areas than is usual and these are not strikingly black but dark brown, and more or less covered by silvery pubescense. The pattern must still be called typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::120:30:38:25.

Female: 1st:2nd:3rd:4th::112:26:35:25.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	6.57 mm.	5.57 mm.	3.24 mm.	1.33 mm.
Female	6.19 mm.	5.38 mm.	3.43 mm.	1.38 mm.

Middle leg	Femur	Hind leg	Femur
Male	18.57 mm.	Male	21.90 mm.
Female	17.14 mm.	Female	18.48 mm.

Male holotype: Length of pregenital abdominal segments:Genital segments::79:78. Genital segments: Suranal plate with median lobe small not surpassing lateral wings which are moderately long and narrow, their front and rear margins not parallel. Pygofer as seen from below long and slender, its tip pointed. Dorsolateral projection slender, barely surpassing the lateral wing of the suranal plate. Shaft of paramere relatively longer and more slender than in *P. harpyia harpyia* and the arm relatively shorter with its tip turned out instead of inward as viewed from the rear, and its sides not parallel.

Female: Length of thorax:Abdomen::115:143. Connexival spine about as long as tergite of seventh abdominal segment and arises from the end of the connexivum. Both dorsolateral and ventrolateral lobes present. Dorsolateral lobe rather long, its upper margin from base of connexival spine to its tip much less than twice as long as the connexival margin of seventh abdominal segment. Incission between the dorsolateral and ventrolateral lobes not as deep as broad. Ventrolateral lobe not as broad as in typical *P. harpyia* Schmidt. See Plate XIX fig. 6.

Comparative notes: When a longer series of this form are taken from Ceram it may prove to be a distinct species.

Types: Holotype male and allotype bear the label "Piroe, Ceram. F. Muir Feb. 1909," in California Acad. Sci. Mus.

Distribution: Known only from the types which came from the Island of Ceram.

Ptilomera (*Ptilomera*) *harpyia ceramensis* n. subsp.

FIG. 1. Female allotype, dorsal view.

FIG. 2. Male holotype, ventral view of genital segments.

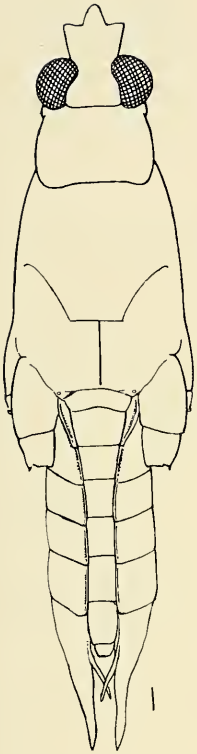
FIG. 3. Male holotype, dorsal view.

FIG. 4. Female allotype, ventral view of sixth and seventh abdominal segments.

FIG. 5. Male holotype, rear view of arm of left paramere.

FIG. 6. Female paratype, side view of sixth and seventh abdominal segments.

PLATE XIX



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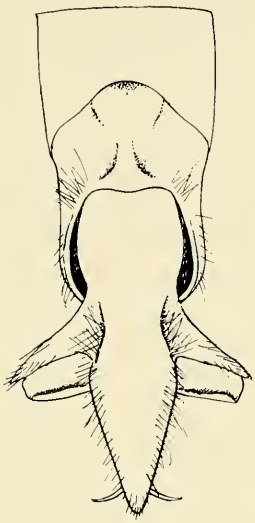

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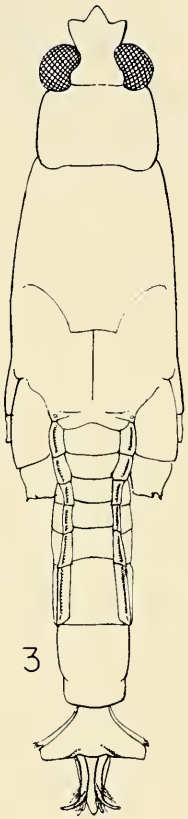

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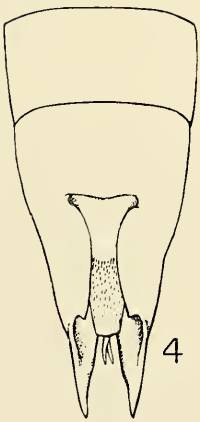

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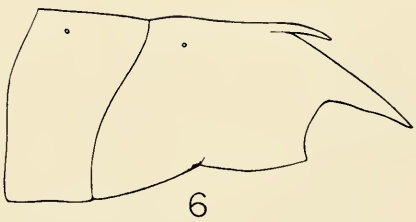


6

Ptilomera sumbaensis n. sp.

Plate XX

Size: Male (apterous): Length 16.67 mm.; width of head 2.57 mm.; width of pronotum 2.71 mm.; length of mesonotum 3.1 mm.; greatest width of body across mesoacetabula 4.52 mm. Female (apterous). Length 14.1 mm.; width of head 2.24 mm.; width of pronotum 2.24 mm.; length of mesonotum 2.95 mm.; greatest width of body across mesoacetabula 4.43 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.
Male: 1st:2nd:3rd:4th::158:40:48:36.
Female: 1st:2nd:3rd:4th::127:32:38:28.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male paratype	8.81 mm.	7.23 mm.	4.19 mm.	1.81 mm.
Female paratype	6.86 mm.	5.76 mm.	3.48 mm.	1.57 mm.

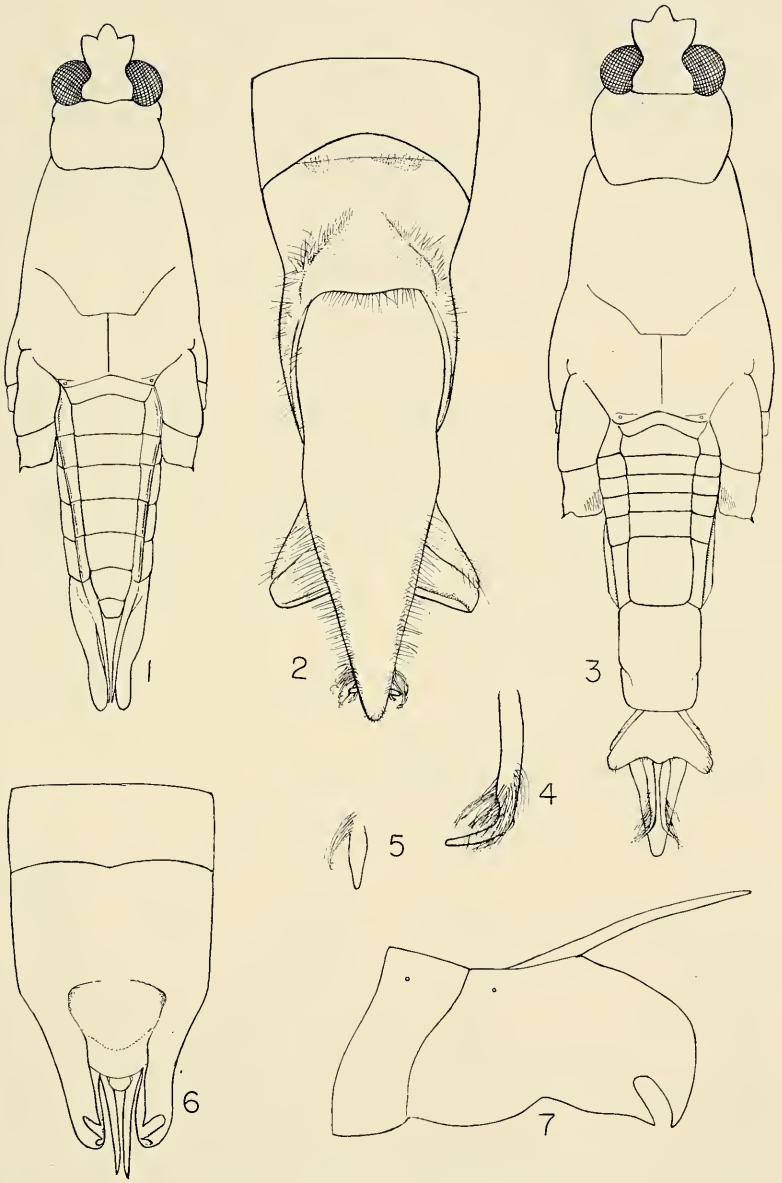
Middle leg	Femur	Hind leg	Femur
Male paratype	23.57 mm.	Male paratype	28.19 mm.
Female paratype	18.29 mm.	Female paratype	19.81 mm.

Male. Length of pregenital abdominal segments:Genital segments::80:107. Hind coxae reaching rear margin of fifth tergite. Genital segments: Suranal plate with median lobe small, lateral wings plainly surpassing median lobe, front and rear margins of lateral wing nearly parallel. Pygofer, as seen from below rather elongate, its dorsolateral projections short, not extending laterally beyond the lateral wings of suranal plate. Caudal end of pygofer with sides converging and tip roundly pointed and obliquely turned dorsad as seen from the side. Dorsolateral projections of pygofer before its middle. Shaft of paramere longer than arm which is turned more or less downward.

Female. Length of thorax:Abdomen::115:140. Seventh abdominal tergite nearly as long as the sixth. Connexival spines moderately long, arising from the end of the connexivum. Dorsolateral lobe of seventh segment with its upper margin from base of connexival spine to its tip broadly curved. The dorsolateral lobe broad at base and turned ventrad. The incission between dorsolateral and ventrolateral lobes deep and narrow.

Comparative notes: This species is a near relative of *P. pamphagus* and in the key runs out near it for both male and female. The males have the hind coxae reaching to or beyond the rear margin

PLATE XX



Ptilomera (*Ptilomera*) *sumbaensis* n. sp.

FIG. 1. Female, dorsal view.
FIG. 2. Male, ventral view of genital segments.
FIG. 3. Male, dorsal view.
FIG. 4. Side view of left paramere.
FIG. 5. Rear view of left paramere arm.
FIG. 6. Female, ventral view of sixth and seventh abdominal segments.
FIG. 7. Female, side view of sixth and seventh abdominal segments.

of the fifth abdominal tergite which is a distinctive feature. The females of both species have the short dorsolateral lobe directed ventrad and are separated in couplet 42 in the key.

Types: Male holotype (apterous), apterous allotype and 4 ♂ ♂, 4 ♀ ♀, apterous paratypes, all bearing the label "Langgai, O. Sumba July 13, 1949. Dr. Bühler and Dr. Sutter." Holotype, allotype and 3 ♂ ♂ and 3 ♀ ♀ paratypes are in the Natural History Museum, Basel, Switzerland. One pair of paratypes are in the K. U. collection.

Distribution: Known only from the type locality.

Ptilomera maai n. sp.

Plate XXI

Size: Male holotype (apterous): Length 15.85 mm.; width of head 2.24 mm.; width of pronotum 2.33 mm.; length of mesonotum 3.33 mm.; greatest width of body across mesoacetabula 3.71 mm.

Female (deälated macropaterous): Length 14.05 mm.; width of head 2.1 mm.; width across humeri 3.05 mm.; greatest width of body across mesoacetabula 3.57 mm.

Color: Typical for the genus but these two specimens show more of the ground color than is usual.

Structural characteristics: Relative lengths of the antennal segments.

Male: 1st:2nd:3rd:4th::150:38:?: ?.

Female: 1st:2nd:3rd:4th::125:29:41:31.

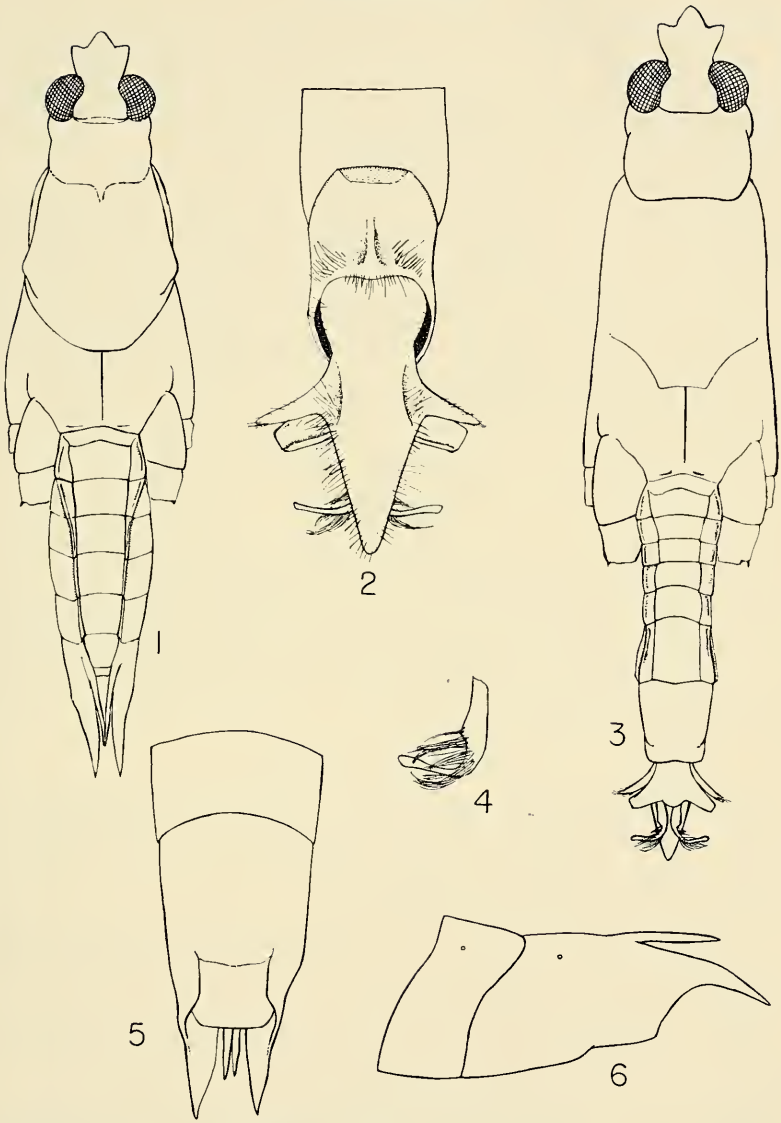
Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male holotype	8.57 mm.	7.29 mm.	4.52 mm.	1.81 mm.
Female allotype	6.66 mm.	5.62 mm.	3.24 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male holotype	24.29 mm.	Male holotype	28.81 mm.
Female allotype	18.33 mm.	Female allotype	20.48 mm.

Male. Length of pregenital abdominal segments:Genital segments::88:78. Genital segments: Suranal plate with median lobe small, surpassed caudally by the lateral wings, the front and rear margins of which are not parallel. Pygofer as seen from below appearing narrow, dorsolateral projections slender, extending a little laterad of wings of suranal plate. Tip of pygofer nearly pointed. Paramere with exposed shaft shorter than its arm. Hind coxae only reaching rear margin of fourth abdominal tergite.

PLATE XXI



Ptilomera (*Ptilomera*) *maai* n. sp.

FIG. 1. Female allotype (deälated macropterous form). Compare with Fig. 3.

FIG. 2. Male holotype, ventral view of genital segments.

FIG. 3. Male holotype (apterous), dorsal view.

FIG. 4. Left paramere.

FIG. 5. Female allotype, ventral view of sixth and seventh abdominal segments.

FIG. 6. Female allotype, side view of sixth and seventh abdominal segments.

Female. The length of thorax:Abdomen::115:135. Seventh abdominal tergite a little shorter than the sixth. Connexival spines of median length arising from end of connexivum. Dorsolateral lobe moderately long, ventrolateral lobe but faintly indicated. Distal lobe of seventh abdominal sternite of usual size and turned vertically, two short parallel ridges near its base.

Comparative notes: In the key to males this species runs out to couplet 21 with *P. sumbaensis* n. sp. and in our key to females to couplet 50 with *P. nunikaensis* n. sp. which also occurs in Borneo.

Types: The holotype and allotype which are apterous, carry the label "Borneo: Sarawak. Kampong Pueh, Lundu District 690-1500 m. May 25-31, 1958 T. C. Maa." These are in Bernice P. Bishop Museum, Honolulu, Hawaii.

Distribution: Known only by the above type locality.

Ptilomera (*Ptilomera*) *pamphagus* Breddin

Plate XXII

1901. *Ptilomera pamphagus* Breddin, Abh. Naturf. Ges. Halle, Bd. 24(20):86-87. Taf. 1 fig. 10. (Described ♀, ♂ from Celebes).
1927. *Pitlomera pamphagus*, Esaki, Eos, Rev. Esp. Ent. 3(3):261.
1933. *Ptilomera pamphagus*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372-373, 518, 420-421, 426-429, figs. 136, 137. (Gave as synonyms: *P. oribasus* Breddin, *P. laelaps* Breddin, *P. sumizome* Esaki).
1960. *Ptilomera pamphagus*, Matsuda, Univ. of Kansas Sci. Bull. 41(2):267, 539 (figs. 623, 625) 541 fig. 635.

Redescription of the types:

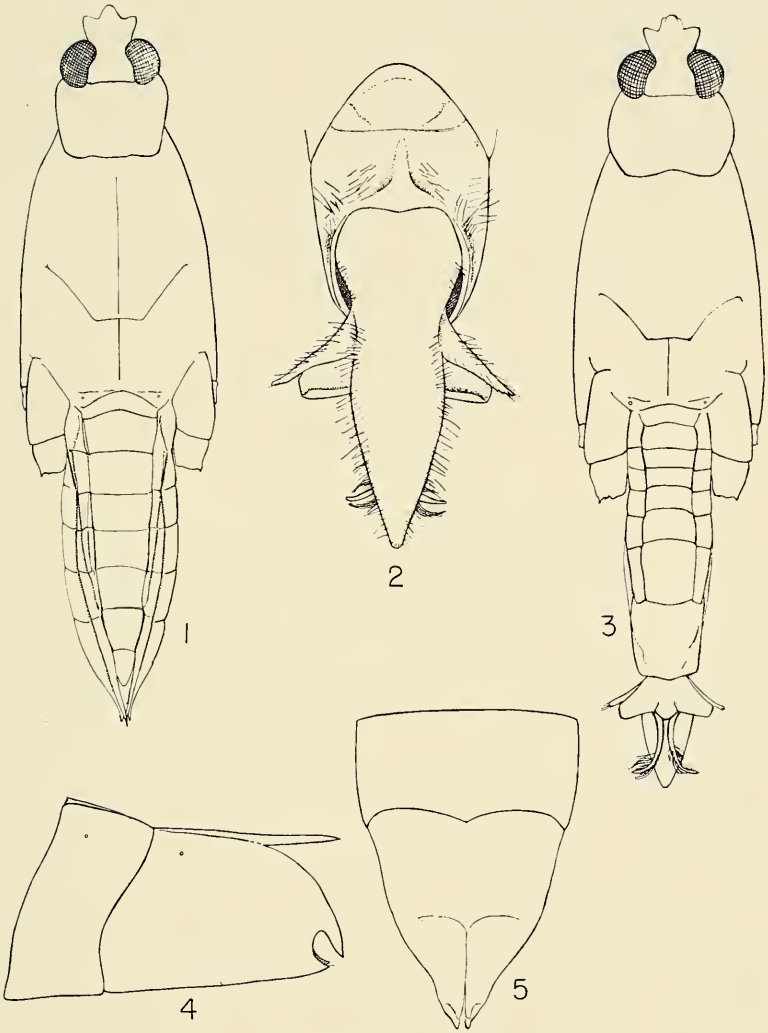
Size: Breddin gave the following: Length of female 15.00 mm.; length of middle femur 21.00 mm.; hind femur 22.5 mm.; length of male 16.5 mm.; length of middle femur 23.5 mm.; hind femur 28.5 mm. Our measurements follows:

Female. Length 15.23 mm.; width of head 2.26 mm.; width of pronotum 2.43 mm.; length of mesonotum 3.38 mm.; greatest width of body across mesoacetabula 4.12 mm.

Male. Length 16.76 mm.; width of head 2.43 mm.; width of pronotum 2.76 mm.; length of mesonotum 3.33 mm.; greatest width of body across mesoacetabula 4.00 mm.

Color: Quite typical for the genus. Head and thorax yellowish brown with the usual black markings. Head with clypeus, antennal sockets and two converging lines on vertex black. The black band on anterior margin of pronotum, anterior lateral margins of meso- and metanotum largely covered by a silvery silky pubescence. The lateral black band of thorax and abdomen with conspicuous band

PLATE XXII



Ptilomera (*Ptilomera*) *pamphagus* Breddin

FIG. 1. Female holotytpe, dorsal view.

FIG. 2. Male allotype, ventral view of genital segments. Note that the dorsolateral projections of pygofer extend at least one-fifth of their length beyond the lateral wings of suranal plate.

FIG. 3. Male allotype, dorsal view. Note the long, slender nearly crescent shaped paramere, their shafts and arms are inseparable.

FIG. 4. Female type, left side view of sixth and seventh abdominal segments.

FIG. 5. Female type, ventral view of sixth and seventh abdominal segments.

of silvery pubescence. Abdominal tergites black, with a median yellowish spot on segments two to seven in female and first six entirely black in male. The black area largely covered by silvery pubescence. Connexivum testaceous. Antennae dark brown to nearly black. Front femur testaceous with two dark longitudinal banks on the dorso-caudal side and a fainter one on the anterior ventral side. Other legs dark brown, the distal ends of femora paler. Entire venter covered with a silvery pubescence.

Structural characteristics: Relative lengths of antennal segments.
Female: 1st:2nd:3rd:4th::138:33:44.3:30.7.
Male: 1st:2nd:3rd:4th::152:38:46:34.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female	7.47 mm.	6.29 mm.	4.10 mm.	1.86 mm.
Male	8.1 mm.	7.14 mm.	4.19 mm.	1.81 mm.

Middle leg	Femur	Hind leg	Femur
Female	21.19 mm.	Female	23.57 mm.
Male	24.29 mm.	Male	29.29 mm.

Female type. Length of thorax:Abdomen::130:148. Seventh abdominal tergite about equal to sixth. Connexival spine moderately long, arising from end of connexivum. Incission between the dorsolateral and ventrolateral lobes narrow and deep. Dorsolateral lobe short and definitely turned ventrad. Distal lobe of seventh abdominal sternite normal in size, directed dorsad and embraced by the lateral lobes.

Male allotype. Length of pregenital abdominal segments:Genital segments::91:83. Genital segments: Suranal plate with median lobe moderate in size, not plainly surpassing lateral lobes, the front and rear margins of which are not parallel. Pygofer as seen from below rather long and slender, its tip bluntly pointed. Dorsolateral projections of pygofer slender and long, in dorsal view extending one-fifth their length beyond the lateral wings of suranal plate. Paramere long and slender, its shaft and arm in one continuous curve, very unlike that of Lundblad's fig. 137 of a specimen from Sumatra which we have named *Ptilomera lundbladi* n. sp.

Comparative notes: This species is distinct from all others. The long, slender dorsolateral projection of the pygofer separates the male from other species and the lateral profile of seventh abdominal segment separates the female from other species.

Types: The types are apterous specimens. The female bears the label "Posso See 900 m. 9, II 95" and Breddin mentioned this as the

type locality in Celebes for *P. pamphagus,* and the specimen fits his figure. However, Breddin had labeled this specimen "*Ptilomera dorceus* Bredd. Typus," and Lundblad has correctly labeled it *Ptilomera pamphagus* and added a red label "Typus." The true type of *Ptilomera dorceus,* is an apterous female, was stated by Breddin to have come from "Matinang-Kette Südseite 800-1200 m. (Sar." Although Dr. Lundblad overlooked this type specimen we found it labeled by him *Ptilomera orbasus* Breddin, and have redescribed and illustrated it. The male type of *P. pamphagus* bears a label "Posso See" and was recognized by Lundblad as this species and he placed a red "Typus" label and his own determination label upon it.

Distribution: Known only from the type localities in Celebes.

Ptilomera (*Ptilomera*) *sumizome* * Esaki

Plate XXIII

1925. *Ptilomera sumizome* Esaki, Philippine Jour. Sci. 26(1):59, Pl. 1, fig. 7(♂), fig. 8(♀). (Described from South-East Celebes.)
1927. *Ptilomera sumizome* Esaki, Eos, Rev. Esp. Ent. 3(3):261.
1933. *Ptilomera sumizome* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 419. (Made this a synonym of *P. pamphagus* Breddin).

Dr. Lundblad did not see the types of this species, but placed it as a synonym of *P. pamphagus* Breddin because it falls within the wide range of variability of the female he ascribed to *P. pamphagus* Breddin. Since Dr. Esaki described his species as black we questioned this synonymy for we had never seen a truly black species.

Thanks to the kindness of Mr. T. Hidaka we have been permitted to study the holotype male and a paratype female of this species which bear the labels "S. O. Celebes T. Elbert 2, 1, 1900, 31" and "Property of the Ent. Lab. Kyushu Univ." We find the types are not really black, but such a dark chocolate brown that the black spots of the generic pattern are inconspicuous, but as usual, covered with a silvery pile. The structural characters show this to be a distinct species.

Redescription of types:

Size: Male holotype (apterous): Length 14.29 mm.; width of head 2.24 mm.; width of pronotum 2.57 mm.; length of mesonotum 3.1 m.; greatest width of body across mesoacetabula 3.57 mm.

Female paratype (apterous): Length 13.14 mm.; width of head 2.05 mm.; width of pronotum 2.05 mm.; length of mesonotum 2.86 mm.; greatest width of body across mesoacetabula 3.48 mm.

* In the Japanese language sumizome means "stained with Chinese ink which is black."

Ptilomera (*Ptilomera*) *sumizome* Esaki

FIG. 1. Female paratype.

FIG. 2. Male holotype, ventral view of genital segments.

FIG. 3. Male holotype, dorsal view.

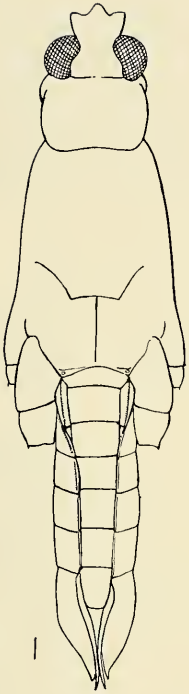
FIG. 4. Male holotype, lateral view of genital segments. Note the elevated caudal section of the dorsum of first genital segment.

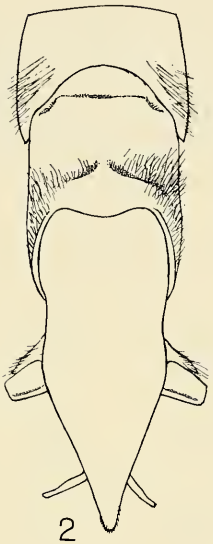
FIG. 5. Female paratype, ventral view of distal abdominal segments.

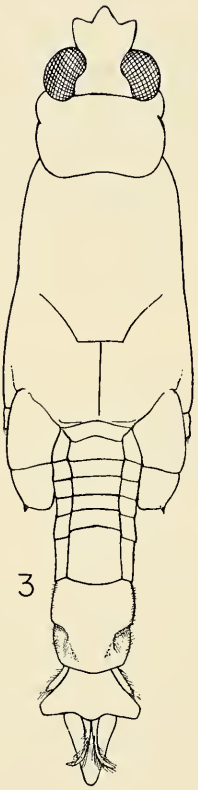
FIG. 6. Female paratype, lateral view of right side of distal abdominal segments.

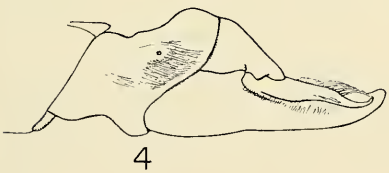
FIG. 7. Male holotype parameres.

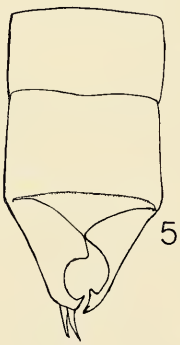
PLATE XXIII

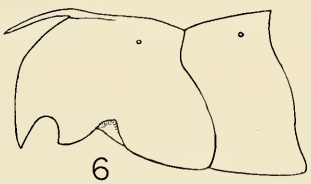












Color: Ground color dark chocolate brown, nearly black. The black spot pattern which characterizes this genus very faint but marked by the silvery pubescence which usually cover such spots. Antennae and legs also nearly black, with the longitudinal black lines of the front femur faintly discernible. In lateral view all acetabula black, more or less covered by silvery pubescence. The longitudinal black band of meso- and metapleura covered medially by a band of long silvery pubescence. Ground color of venter of thorax and abdomen black, almost obscured by a frosty pubescence.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::140:33:42:28.

Female: 1st:2nd:3rd:4th::120:31: ?: ?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male (holotype)	7.43 mm.	6.29 mm.	3.8 mm.	1.62 mm.
Female (paratype)	6.29 mm.	5.33 mm.	3.05 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Male (holotype)	21.33 mm.	Male (holotype)	25.71 mm.
Female (paratype)	17.71 mm.	Female (paratype	19.28 mm.

Male holotype. Length of pregenital abdominal segments:Genital segments::65:78. Genital segments: Suranal plate with median lobe small, but slightly surpassing the lateral wings; lateral wings short, their anterior and posterior margins not parallel. Pygofer with its dorsolateral projections before its middle and not longer than the lateral wings of suranal plate when viewed from above; distal half of pygofer slender, its caudal tip pointed. Paramere very hairy, its exact shape difficult to see, but both shaft and arm are stout, the latter rounded at tip. (See Plate XXIII, fig. 7.) Distal half of dorsum of first genital segment abnormally elevated.

Female paratype. Length of thorax:Abdomen::116:132. Seventh abdominal tergite a little shorter than sixth. Connexival spine of moderate length, arising from the end of the connexivum. Both dorsolateral and caudolateral lobes present, the former short and directed ventrad. An incission separating the lobes moderately narrow. (Plate XXIII fig. 6).

Comparative notes: In the key to males this species runs out in couplet 24 with *P. harypia* Schmidt and in the key to females it runs out in couplet 41 which leads also to *P. sumbaensis* n. sp. and *P. pamphagus* Breddin.

Types: The types are in the Entomological Laboratory of Kyushu University, Fukuoka, Japan.

Distribution: Known only from the types which came from Southeast Celebes.

Ptilomera (*Ptilomera*) *sumatranus* n. sp.

Plate XXIV

Size: Male holotype (apterous): Length 16.29 mm.; width of head 2.19 mm.; width of pronotum 2.48 mm.; length of mesonotum 3.71 mm.; greatest width of body across mesoacetabula 4.14 mm.

Female allotype (apterous): Length 15.24 mm.; width of head 2.12 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.48 mm.; greatest width of body across mesoacetabula 4.14 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::168:41:55:32.

Female: 1st:2nd:3rd:4th::148:33:41:31.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male	8.48 mm.	7.33 mm.	4.52 mm.	1.76 mm.
Female	7.81 mm.	6.43 mm.	4.33 mm.	1.67 mm.

Middle leg	Femur	Hind leg	Femur
Male	25.24 mm.	Male	30.10 mm.
Female	21.19 mm.	Female	23.10 mm.

Male. Length of pregenital segments of abdomen:Genital segments::84:72. Genital segments: Suranal plate with median lobe of moderate size. Lateral wings of suranal plate not surpassing caudally the median lobe, their front and rear margins not parallel. Pygofer, as seen from below, normal in shape and its caudal tip blunt. Dorsolateral projections of pygofer slender, pointed and extending laterally about as far as lateral wings of suranal plate; shaft of paramere longer than the laterally turned arm. In rear view the arm has a distinct keel on its lower margin as shown on Plate XXIV fig. 4.

Female. Length of thorax:Abdomen::130:158. Seventh abdominal tergite subequal to the sixth tergite. Connexival spine of moderate length arising from end of connexivum. Dorsolateral lobe short, directed obliquely downward, separated from ventrolateral lobe by a narrow deep incission. The distal lobe of seventh abdominal sternite of usual size and shape and partly covered by the lateral lobes. If seen from the rear its distal margin is truncate and not pointed.

Ptilomera (*Ptilomera*) *sumatranus* n. sp.

FIG. 1. Female allotype, dorsal view.

FIG. 2. Male holotype, ventral view of genital segments.

FIG. 3. Male holotype, dorsal view.

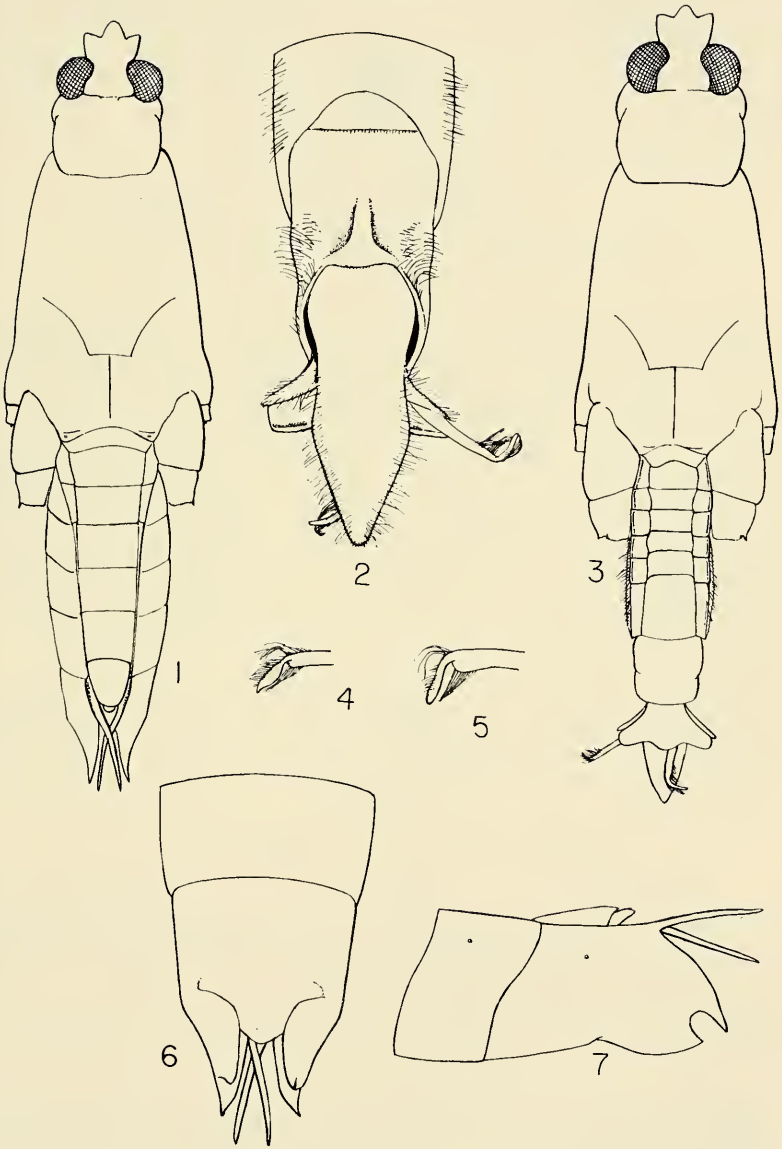
FIG. 4. Rear view of left paramere.

FIG. 5. Side view of right paramere.

FIG. 6. Female allotype, ventral view of sixth and seventh abdominal segments.

FIG. 7. Female allotpe, left side view of sixth and seventh abdominal segments.

PLATE XXIV



Comparative notes: This is one of several closely related species from Sumatra that would be puzzling if not accompanied by males.

Types: An apterous holotype male and an apterous female allotype and two paratypes (♂ - ♀) bear the label: "Sud-Sumatra, Lampongs. Mt. Tenggamoes. M. E. Walsh, 15-2000 ft." The holotype and allotype are in the Natural History Museum, Basel, Switzerland. Doctors Sutter and Keiser have given the paratypes to University of Kansas collection.

Distribution: Known only from the type locality.

Ptilomera (*Ptilomera*) *lundbladi* n. sp.

Plate XXV

Lundblad's fig. 136B and 137 were reproduced from Archiv für Hydrobiologie, Suppl. Bd. 12:427-428 (1933). In fig. 136B is a side view figure of the seventh segment of a female that came from Subang Ajam, Sumatra that Dr. Lundblad figured as only a variation of *P. pamphagus* Breddin. In fig. 137 he figured the genitalia of a male from the same place and labeled it *P. pamphagus*. Had he examined the paramere of the type of *P. pamphagus* he would have found that the male from Celebes is quite unlike his male from Sumatra. Therefore, we offer the name *P. lundbladi* for the species indicated above identified by Lundblad as *Ptilomera pamphagus* which it cannot be.

By the generosity of Dr. O. Lundblad of Stockholm, Sweden, we have been permitted to reproduce his text figures 136 and 137 on this plate. Since figure 136B and figure 137 are not *P. pamphagus* Breddin but an undescribed species we have named it in his honor.

Ptilomera (*Ptilomera*) *laelaps* Breddin

Plate XXVI

1901. *Ptilomera laelaps* Breddin, Abh. Naturf. Ges, Halle, 24:20, 88-89. Taf. 1, fig. 13 (Lists on p. 20, described male from Celebes on pp. 88-89).
1903. *Ptilomera laelaps*, Breddin, Societas Entomologica 17(19):147. (Described female from Samanga, S. Celebes).
1927. *Ptilomera laelaps*, Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera laelaps*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372-73, 419-21. (Gave as synonym of *P. pamphagus*).

In his paper "Die Hemipteren von Celebes" Dr. Breddin described the male from "S. Loka, 1000-3000 m. Okt. 95 (Sar); Makassar (Coll. Breddin)." In 1903 he described the female from

PLATE XXV

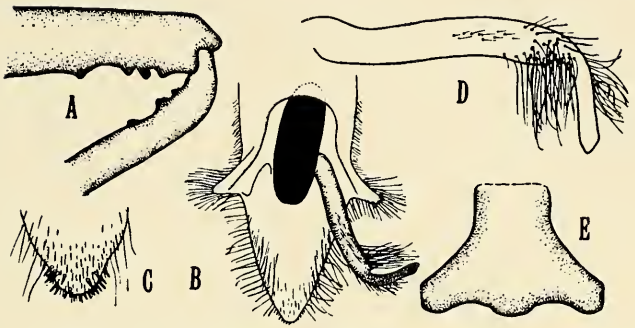


Fig. 137. *Ptilomera pamphagus* Bredd. ♂ (apter).
A Kniegelenk des Vorderbeins; B Genitalkapsel von oben (Penis schwarz; linker Genitalgriffel entfernt); C Distalende der Genitalkapsel; D linker Genitalgriffel; E Analplatte.
Nach einem Expl. aus Subang Ajam, Tjurup, Sumatra.

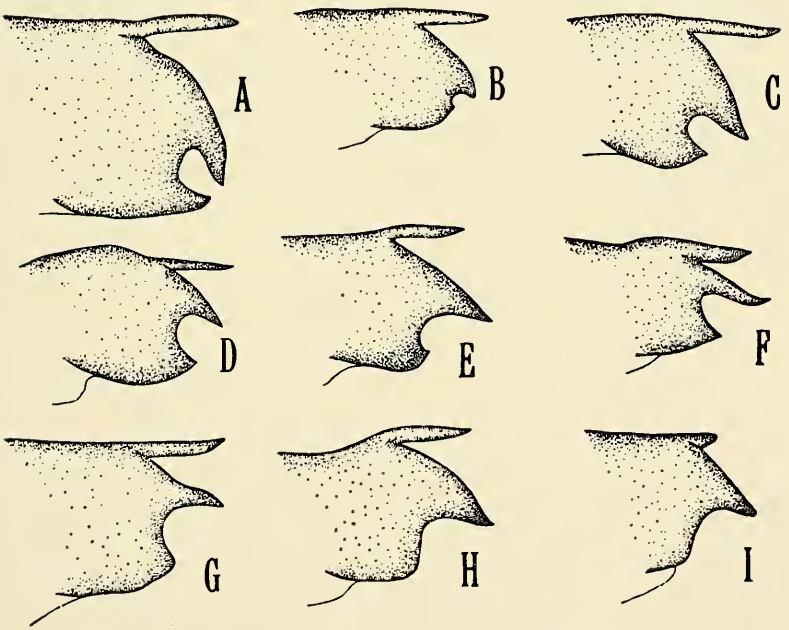


Fig. 136. *Ptilomera pamphagus* Bredd. ♀♀ (apter).
A die Type von *pamphagus;* B nach einem Expl. aus Subang Ajam, Sumatra; C—D aus dem Wai Negri, Sumatra; E aus Balige, Sumatra; F aus Umbilin, Sumatra; G die Type von *oribasus;* H aus Balige, Sumatra; I die Type von *laelaps.*

Ptilomera (*Ptilomera*) *laelaps* Breddin

FIG. 1. Female allotype, dorsal view. Note the very short connexival spines.

FIG. 2. Female allotype, ventral view of sixth and seventh abdominal segments.

FIG. 3. Male holotype, dorsal view.

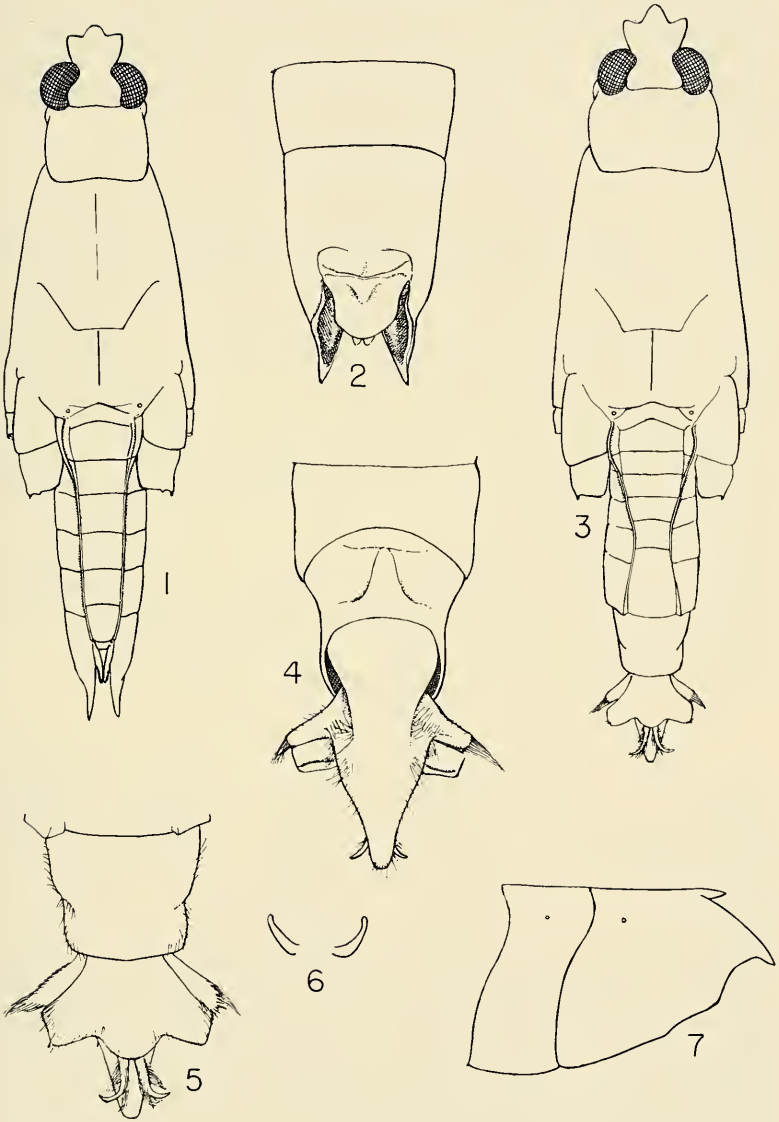
FIG. 4. Male holotype, ventral view of genital segments.

FIG. 5. Male holotype, dorsal view of genital segments.

FIG. 6. Male holotype, rear view of arms of the parameres.

FIG. 7. Female allotype, side view of sixth and seventh abdominal segments.

PLATE XXVI



S. Celebes (Samanga). Fortunately, we found in our Kirkaldy Collection 1 apterous male and 3 apterous females and one macropterous male bearing the identical label of the female type "Samanga S. Celebes Nov. 1895 H. Fruhstorfer" and one apterous male bearing the label "S. Celebes Bua-Kraeng 5000 ft. Feb. 1896, H. Fruhstorfer." The males of our series are like the male type and the three females are like the female type and show no recognizable variation in the length of the connexival spine.

Redescription

Size: Female type (apterous): Length 14.38 mm.; width of head 2.02 mm.; width of pronotum 2.10 mm.; length of mesonotum 2.90 mm.; greatest width of body across mesoacetabula 3.62 mm.

Male (apterous): Bearing the same collector's label as the female type. Length 15.24 mm.; width of head 2.10 mm.; width of pronotum 2.43 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesoacetabula 3.71 mm.

Male (macropterous): From the same place as above. Length including wings 15.14 mm.; width across head 2.10 mm.; width across humeri 3.14 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.
Female type (apterous): 1st:2nd:3rd:4th::125:28:40:27.
Male (apterous): 1st:2nd:3rd:4th::132:33.5:43:30.
Male (macropterous): 1st:2nd:3rd:4th::123:32:40:29.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female type	6.90 mm.	5.71 mm.	3.33 mm.	1.48 mm.
Male (apterous)	7.29 mm.	6.19 mm.	3.43 mm.	1.52 mm.
Male (macropterous)	6.86 mm.	5.81 mm.	3.10 mm.	1.43 mm.

Middle leg	Femur	Hind leg	Femur
Female type	19.1 mm.	Female type	20.5 mm.
Male (apterous)	20.47 mm.	Male (apterous)	24.00 mm.
Male (macropterous)	18.57 mm.	Male (macropterous)	21.67 mm.

Male. Length of pregenital abdominal segments:Genital segments::80:62. Genital segments: Suranal plate not large but surpassing caudally broad short lateral wings which have their front and rear margins not parallel. Pygofer with its dorsolateral projections short; pygofer, as seen from below, not conspicuously broad beyond its middle, its venter of usual shape and its tip roundly pointed. Paramere with shaft relatively slender and not sharply separated from its arm, not shaped like that of *P. harpalos*

Schmidt which runs out also in couplet 19 of the key. First genital segment with its dorsal line but little elevated in caudal half as seen from side; venter short, its median longitudinal keel broad.

Female. Length of thorax:Abdomen::128:148. Seventh abdominal tergite as long as sixth. Connexival spine stout, short, plainly shorter than seventh tergite, not half as long as upper margin of dorsolateral lobe from base of connexival spine to its tip. Dorsolateral and ventrolateral lobes short, the latter represented by a convex curve in caudal margin and separated from the former by a broad shallow incission. Dorsolateral lobe directed obliquely downward. Distal lobe of seventh sternite moderately small, its sides slightly converging and slightly concave, its distal end slightly convex.

Comparative notes: This species is related to *P. harpalos* Schmidt and runs out to couplet 19 in the key to males and to couplet 15 in the key to females.

Types: One apterous male one apterous female. Types are in the Deutsches Entomologisches Institut, Berlin.

Distribution: Besides the types we have one apterous male and three apterous females and one macropterous male bearing the identical label of the female type. "Samanga, S. Celebes Nov. 1895 H. Fruhstorfer" and one apterous male bearing the label "S. Celebes, Bua-Kraeng 5000 ft. Feb. 1896 H. Fruhstorfer."

Ptilomera (*Ptilomera*) *harpalos* Schmidt

Plate XXVII

1926. *Ptilomera harpalos* Schmidt, Ent. Mitt. 15(1):66. (Described from Sumatra).
1927. *Ptilomera harpalos,* Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera harpalos,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 373, 419, 420.
1960. *Ptilomera harpalos,* Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 539, fig. 627.

Redescription:

Size: Schmidt gives the length of male type 15.5 mm.; greatest width 4.00 mm.; hind femur 27.00 mm. Length of female 15.5 mm.; greatest width 3.5-4.0 mm. (he had two females); hind femur 23.00 mm. We give the following measurements for the types. We must accept Schmidt's measurement for the length of body because he removed and mounted the genital segments on slides.

Male type (apterous): Length 15.5 mm.; width of head 2.14 mm.; width of pronotum 2.33 mm.; length of mesonotum 3.67 mm.; great-

Ptilomera (*Ptilomera*) *harpalos* Schmidt

FIG. 1. Female from Sumatra, Si Rambé. Dorsal view.

FIG. 2. Male type. Genital segment drawn from slide mount.

FIG. 3. Male from Sumatra, Si Rambé. Dorsal view.

FIG. 4. Female from Sumatra, Si Rambé. Ventral view of sixth and seventh abdominal segments.

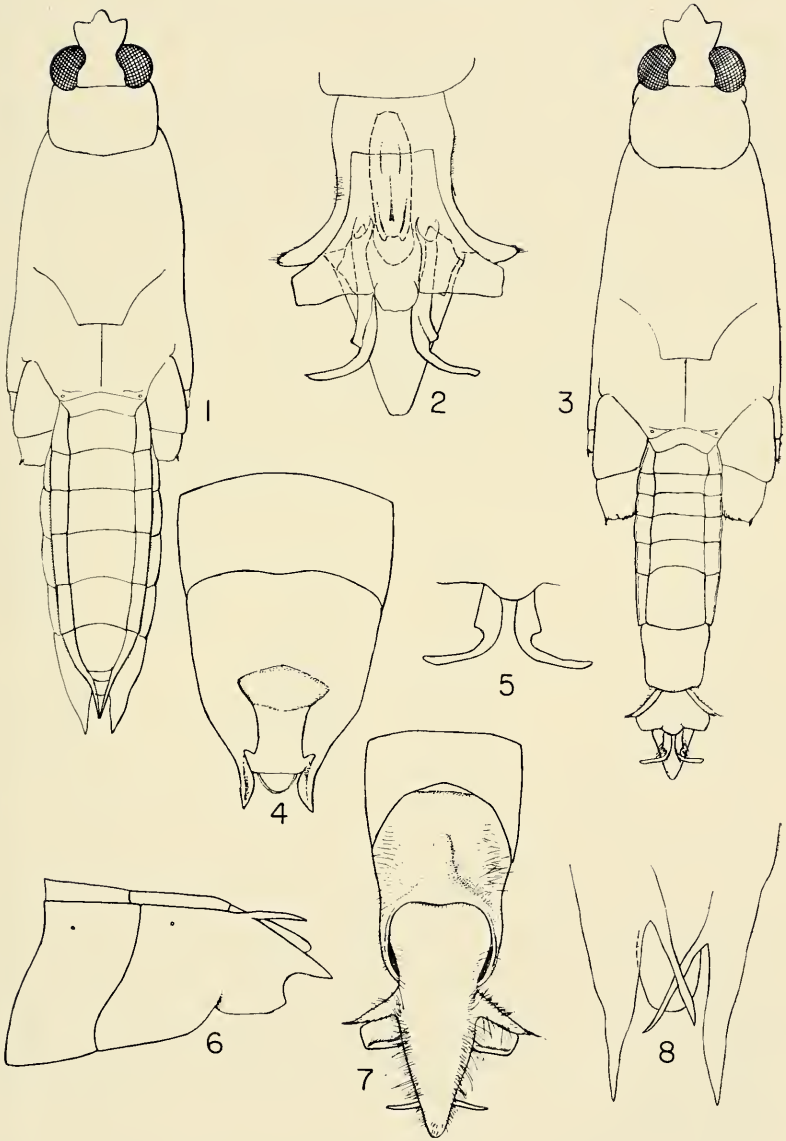
FIG. 5. Male from Sumatra, Si Rambé. Enlarged drawing of paramere of figure 3.

FIG. 6. Female from Sumatra, Si Rambé. Side view of sixth and seventh abdominal segments.

FIG. 7. Male from Sumatra, Si Rambé. Ventral view of genital segments.

FIG. 8. Female type. Dorsal view of abdominal tip drawn from slide mount.

PLATE XXVII



est width of body across mesoacetabula 3.90 mm. Female type (apterous). Length 15.5 mm.; width of head 2.05 mm.; width of pronotum 2.05 mm.; length of mesonotum 3.43 mm.; greatest width of body across mesoacetabula 3.86 mm. We give below the measurements of a pair from our Kirkaldy Collection bearing the label "Dr. Hagen, Toba-meer Sumatra inter."

Male (apterous). Length 14.29 mm.; width of head 2.1 mm.; width of pronotum 2.31 mm.; length of mesonotum 3.48 mm.; greatest width of body across mesoacetabula 3.57 mm. Female (apterous). Length 15.33 mm.; width of head 2.00 mm.; width of pronotum 2.12 mm.; length of mesonotum 3.38 mm.; greatest width of body across mesoacetabula 3.62 mm.

Color: Typical of the genus.

Structural characteristics: Relative lengths of antennal segments.
Male type: 1st:2nd:3rd:4th::147:35: ?: ?.
Female type: 1st:2nd:3rd:4th::138:31:45:32.
Male (Kirk. Coll.): 1st:2nd:3rd:4th::137:37:50:30.
Female (Kirk. Coll.): 1st:2nd:3rd:4th::120:28:37:29.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male type	8.00 mm.	7.14 mm.	4.19 mm.	1.67 mm.
Male (Kirk. Coll.)	7.60 mm.	6.60 mm.	3.90 mm.	1.60 mm.
Female type	7.62 mm.	6.57 mm.	4.00 mm.	1.62 mm.
Female (Kirk. Coll.)	6.80 mm.	5.70 mm.	3.70 mm.	1.52 mm.

Middle leg	Femur	Hind leg	Femur
Male type	22.38 mm.	Male type	28.1 mm.
Male (Kirk. Coll.)	19.38 mm.	Male (Kirk. Coll.)	22.86 mm.
Female type	21.33 mm.	Female type	23.09 mm.
Female (Kirk. Coll.)	17.62 mm.	Female (Kirk. Coll.)	19.52 mm.

Male. Length of pregenital abdominal segments:Genital segments::83:64. Genital segments: Suranal plate not large but surpassing caudally short lateral wings which have their front and rear margins not parallel. Pygofer with its dorsolateral projections short; pygofer as seen from below not conspicuously broad beyond its middle, its venter of usual shape, its tip roundly pointed. Paramere with exposed part of shaft stout, short and broad, its lateral margin abruptly turned mesally to form the base of the arm which turns laterally. First genital segment with its dorsal line nearly straight, caudal half only elevated, venter short, its median longitudinal keel broad.

Female. Length of thorax:Abdomen::125:160. Seventh abdominal tergite about as long as sixth. Connexival spine relatively short, slender and sharp pointed, usually at least half as long as upper

margin of dorsolateral lobe from base of connexival spine to its tip. Dorsolateral lobe stout and short, directed obliquely downward; ventrolateral lobe short, nearly rectangular at tip and separated from dorsolateral lobe by a broad shallow incission that is deeper than that of *P. laelaps* Breddin.

Comparative notes: This species is a near relative of *P. laelaps* Breddin from which it differs in both sexes. The paramere has the exposed portion of its shaft short and broad, with its distolateral margin abruptly turned mesad to form the base of arm. The paramere in *P. laelaps* is different as seen in the key. The female has a longer and more slender connexival spine than in *P. laelaps*.

Types: One male and one female types bear the label "Dohrn Sumatra. Sinabong." One female with the label "Soekaranda, Jan. 1894 Dohrn." All apterous. All types are at the Polish Academy of Sciences, Warsaw, Poland.

Distribution: Besides the types we have the following from Sumatra. "Dr. B. Hagen Toba-meer, Sumatra inter." 1 ♂, 2 ♀ ♀, (all apterous) (K. U. Kirkaldy Collection); "Sumatra Si-Rambe XII 90 III 91 E. Modigliani" 1 ♂, 3 ♀ ♀, (apterous) (K. U. Kirkaldy Collection); "Sibolga Tapianoeli Sumatra 9, 16, 31 v. d. Meer Mohr" 2 ♀ ♀ (apterous) (K. U. Coll.); Near Sembahe, E. coast Sumatra 6.7 '31 v. d. Meer Mohr, 1 ♂ (apterous) (K. U. Coll.).

Ptilomera (*Ptilomera*) *oribasus* Breddin

Plate XXVIII, figs. 1, 2, 3, 5, 6, 7

1901. *Ptilomera oribasus* Breddin, Abh. Naturf. Ges. Halle, Bd. 24:20,88. Taf. 1 fig. 12 ♀. (Described from Celebes).
1927. *Ptilomera oribasus*, Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera oribasus*, Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 373, 419-21. (Gave as synonym of *P. pamphagus* Breddin).

Breddin's collection contains two female specimens, each with a red "type" label. One bears the written label "Celebes. Sudl. Vorberge der Takalekadjo-Kette 1000 m. 7 II 95 Leg. Sarasin," and "*Ptilomera oribasus* Breddin Typus," in Breddin's handwriting. This specimen is the one Breddin drew and also the one Lundblad drew. The other female specimen bears the labels, "Celebes Natinang-Kette Seite 800-1200 m. (Sar.)." It also bears a label "*Ptilomera oribasus* Bred." which is not Breddin's writing. It looks like Dr. Lundblad's printing. He is the only one who has written on these types. However, this female fits Breddin's figure of *Ptilomera dorceus* and bears the type locality label of this species. Dr. Lundblad must have overlooked this specimen because he said on page

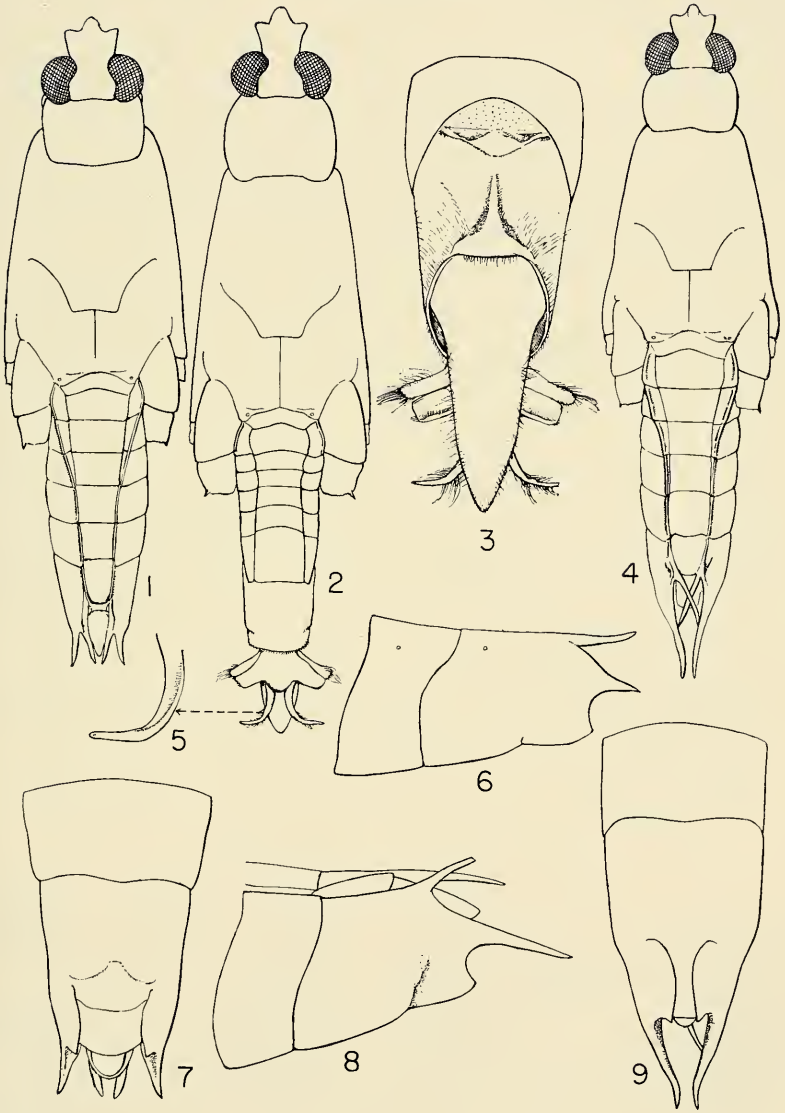
Ptilomera (*Ptilomera*) *oribasus* Breddin

FIG. 1. Female allotype, dorsal view.
FIG. 2. Male neallotype, dorsal view.
FIG. 3. Male neallotype, ventral view of genital segments. (Brit. Mus.)
FIG. 5. Male neallotype, dorsal view of left paramere.
FIG. 6. Female type, side view of sixth and seventh abdominal segments.
FIG. 7. Female type, ventral view of sixth and seventh abdominal segments.

Ptilomera (*Ptilomera*) *dorceus* Breddin

FIG. 4. Female type, dorsal view.
FIG. 8. Female type, lateral view of sixth and seventh abdominal segments.
FIG. 9. Female type, ventral view of sixth and seventh abdominal segments.

PLATE XXVIII



419 of his great work "Zur Kenntnis der Aquatilen und Semiaquatilen Hemipteren von Sumatra, Java, und Bali 1933," that the only species of *Ptilomera* unknown to him were *P. tigrina*, *P. dorceus*, and *P. sumizome*. We have now before us the types of all three of these as well as the type of *P. oribasus* Breddin which is a female.

In addition we have had the good fortune of finding the undetermined material of the British Museum a male and female of this species and have labeled the female "*P. oribasus* Breddin" and "compared with Type." We have labeled the male "*P. oribasus*" "Neallotype." Both specimens bear the label "F. C. Drescher Zuid Celebes Nanggala 900 m. Rantepao VI 1937." Therefore, a more complete description of the species follows:

Size: Female type (apterous): Breddin says length is 14.00 mm.; middle femur 18.5 mm.; hind femur 21.5 mm. Our measurements for this type: Length 13.81 mm.; width of head 2.05 mm.; width of pronotum 2.17 mm.; length of mesonotum 3.05 mm.; greatest width of body across mesoacetabula 3.90 mm.

Male neallotype (apterous): Length 15.71 mm.; width of head 2.31 mm.; width of pronotum 2.43 mm.; length of mesonotum 3.29 mm.; greatest width of body across mesoacetabula 4.09 mm.

Apterous female taken with neallotype. Length 14.86 mm.; width of head 2.14 mm.; width of pronotum 2.24 mm.; length of mesonotum 3.19 mm.; greatest width of body across mesotabula 4.19 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Female type: 1st:2nd:3rd:4th::127:27: ?: ?.

Male neallotype: 1st:2nd:3rd:4th::152:35:48: ?.

Female came with neallotype lost antennae.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female type	7.14 mm.	6.1 mm.	3.57 mm.	1.52 mm.
Male neallotype	7.85 mm.	6.66 mm.	4.38 mm.	1.67 mm.
Female came with above,	7.00 mm.	5.85 mm.		

Middle leg	Femur	Hind leg	Femur
Female type	18.81 mm.	Female type	22.14 mm.
Male neallotype	22.71 mm.	Male neallotype	28.57 mm.
Female came with neallotype	18.81 mm.	Female came with neallotype	20.81 mm.

Female type (apterous). Length of thorax:Abdomen::120:137.

Female came with male neallotype (apterous). Length of thorax: Abdomen::120:140.

Female (apterous). Length of thorax:Length of abdomen::122:146. Seventh abdominal tergite as long as sixth. Connexival spine arising from end of seventh connexivum and at least half as long as upper margin of dorsolateral lobe from base of connexival spine to its tip. An incission separating the dorsolateral and ventrolateral lobes of seventh abdominal segment wide. Dorsolateral lobe short, slender and sharply pointed. Distal lobe of the seventh abdominal sternite of usual size and embraced by lateral lobes.

Male neallotype (apterous). Length of pregenital abdominal segments:Genital segments::78:73. Genital segment: Suranal plate with median lobe not large, but surpassing lateral wings caudally; lateral wing with front and rear margins nearly parallel, the rear margin a little longer than width of its tip. Pygofer with its dorsolateral projections short but surpassing lateral wings of suranal plate and ending in a dense brush of long hair. Pygofer, as seen from below, not broad beyond its middle, but appearing rather elongate and its tip pointed. Venter of genital segments without a complete keel on the first genital.

Comparative notes: This species which came from Celebes appears to have its nearest relatives in New Guinea. See couplet 17 of key to males. However, in the key to females, which is certainly not a phylogenetic key, it is not far removed from two New Guinea forms before it and two New Guinea species after it.

Types: The apterous female type bears the label "Celebes Sudl. Vorberge der Takalekadjo-Kette 1000 m. 7 II 95 Leg. Sarasin." They are in the Deutsches Entomologisches Institut, Berlin. The apterous male neallotype and a female taken with it bear the label "F. C. Drescher. Zuid Celebes Nanggala 900 m. Rantepao VI 1937. These are in the British Museum.

Distribution: Known only from the above type localities.

Ptilomera (*Ptilomera*) *dorceus* Breddin

Plate XXVIII, figs. 4, 8, and 9

1901. *Ptilomera dorceus* Breddin, Abh. Naturf. Ges. Halle, 24:20, 87-88. Taf. 11a, 11b. (Described ♀ from Celebes and figured genital segments.)
1927. *Ptilomera dorceus,* Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera dorceus,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:372, 420.

Dr. Lundblad did not know *P. dorceus* Breddin but believed it to be the same as *P. dromas* Breddin 1903 which he knew. However, since we found what we believe to be four good species on his fig. 136 (all nine drawings of which he thought were variations of *P. pamphagus* Breddin), we are inclined to question some of the

variations of *P. dromas* Breddin in Lundblad's fig. 134. We believe that since we have keyed out the female type of *P. dorceus* Breddin, we must consider it a species until it is taken together with some males from Celebes that prove otherwise. We therefore offer the following notes on this female type:

Size: Breddin gave its body length as 14.00 mm., middle femur 17.5 mm., hind femur 19.5 mm. Our measurements: Length of body 14.29 mm.; width of head 2.05 mm.; width of pronotum 2.12 mm.; length of mesonotum 2.90 mm.; greatest width of body across mesoacetabula 3.67 mm.

Color: Typical for the genus. This specimen has two broad black converging bands on vertex. The black bands on anterior margin of pronotum medially joined. The black band on the side of mesothorax separated by a longitudinal silvery dense pubescence, beneath which there shows no yellow stripe, the usual black band is almost obliterated by white pubescence that continues on the venter.

Structural characteristics: Relative length of antennal segments. Female type: 1st:2nd:3rd:4th::123:29:41:27.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Female type	6.86 mm.	5.9 mm.	3.29 mm.	1.48 mm.
Middle leg	Femur	Hind leg		Femur
Female type	18.19 mm.	Female type		19.52 mm.

Female. Length of thorax:Abdomen::112:152. Seventh abdominal tergite slightly longer than sixth. Connexival spine moderately long, arising from end of connexivum. Incission between dorso- and ventrolateral lobes not as deep as broad. Dorsolateral lobe of seventh abdominal segment only moderately long, its upper margin from base of connexival spine to its tip much less than twice as long as connexival margin of seventh abdominal segment. The dorsolateral lobe rather slender and spine-like. The ventrolateral lobe short, bluntly pointed; in side view it is shorter than the venter of the seventh abdominal segment; in ventral view the ventrolateral lobe is not broad. Distal lobe of seventh abdominal sternite of usual size and shape, directed vertically and embraced by the lateral lobes. We regret that the male of this Celebes species is unknown.

Comparative notes: This species must be a near relative of *P. dromas* Breddin from Java but until we have both males and females of this species from Celebes we cannot determine how near.

Type: Apterous female from "N. Celebes, Matinang-Kette Sudseite 800-1200 m. (Sar)." In the Deutsches Entomologisches Institut, Berlin.

Distribution: Known only from the above place.

Ptilomera (*Ptilomera*) *dromas* Breddin

Plates XXIX and XXX

1901. *Ptilomera dromas* Breddin, Abh. Naturf. Ges. Halle, Bd. 24, Taf. 1, 14 a, b. (While his title was "Die Hemipteren von Celebes" *P. dromas* n. sp. came from Java as he explained in 1903).
1903. *Ptilomera dromas* Breddin, Soc. Ent. 17(9):147. (Refers to above and described male and female from East and South Java).
1905. *Ptilomera dromas* Breddin, Mitt. Naturh. Mus. Hamburg, 22:131-32. (Redescribed both sexes from Java.).
1915. *Ptilomera dromas,* Bergroth, Zool. Med. Leiden, 1-3:123. (Noted that Distant and old authors figured male as female and vice versa in this genus).
1927. *Ptilomera dromas,* Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1929. *Ptilomera dromas,* Dover, Treubia 10(1):69.
1933. *Ptilomera dromas,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:423, Taf. 13, figs. 134-35. (Suggested that *P. argus* Breddin and *P. asbolus* Breddin are synonym and we agree).
1960. *Ptilomera dromas,* Matsuda, Univ. Kansas Sci. Bull. 41(2):267, 537, figs. 539, 610, 622.
The following synonymies also belong here.
1903. *Ptilomera argus* Breddin, Societas Entomologica 17(19):147-48. (Described male from W. Java).
1905. *Ptilomera argus* Breddin, Mitt. Naturh, Mus. Hamburg. 22:134. (Repeated description of male in 1903).
1927. *Ptilomera argus,* Esaki, Eos Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera argus,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:371. (Saw type and thought it is only an unusually small example of *P. dromas* Breddin).
1905. *Ptilomera asbolus* Breddin, Mitt. Naturh. Mus. Hamburg 22:132-34, figs. 10-11. (Drawings of male and female genital segments of specimens from Java).
1927. *Ptilomera asbolus,* Esaki, Eos, Rev. Esp. Ent. 3(3):260.
1933. *Ptilomera asbolus,* Lundblad, Arch. Hydrobiol. Suppl. Bd. 12:373, 421. (Said is syn. of *P. dromas* Breddin).

When we first examined the male and female types of *P. dromas* Breddin from East Java, a male of *P. argus* Breddin from West Java, and a female of *P. asbolus* Breddin from Java we found that while *P. asbolus* was described and figured for both sexes the male is not now present in the Breddin collection. We also thought that *P. dromas* and *P. argus* were different species and that *P. asbolus* was a synonym of *P. argus.* However, when we tried to key out *P. dromas* and *P. argus* we found it impossible to do so and have reached the conclusion that both *P. argus* and *P. asbolus* are synonyms of *P. dromas.*

We offer the following descriptions of various types.

PLATE XXIX

Ptilomera (*Ptilomera*) *dromas* Breddin

FIG. 1. Female type, dorsal view.

FIG. 2. Female type, ventral view of sixth and seventh abdominal segments.

FIG. 3. Male type, dorsal view of genital segments.

FIG. 4. Male type, dorsal view.

FIG. 6. Male type, arm of left paramere as seen from the rear.

FIG. 7. Male type, genital segments in ventral view.

FIG. 8. Female type, sixth and seventh abdominal segments as seen from left side.

Ptilomera (*Ptilomera*) *asbolus* Breddin

FIG. 5. Female type, showing sixth and seventh abdominal segments from left side.

Ptilomera (*Ptilomera*) *argus* Breddin

FIG. 9. A female from Buitenzorg, Java, that was taken with males that are the same as the *P. argus* type. Drawing shows sixth and seventh abdominal segments seen from left side.

FIG. 10. The same female showing a ventral view of the same segments.

PLATE XXIX

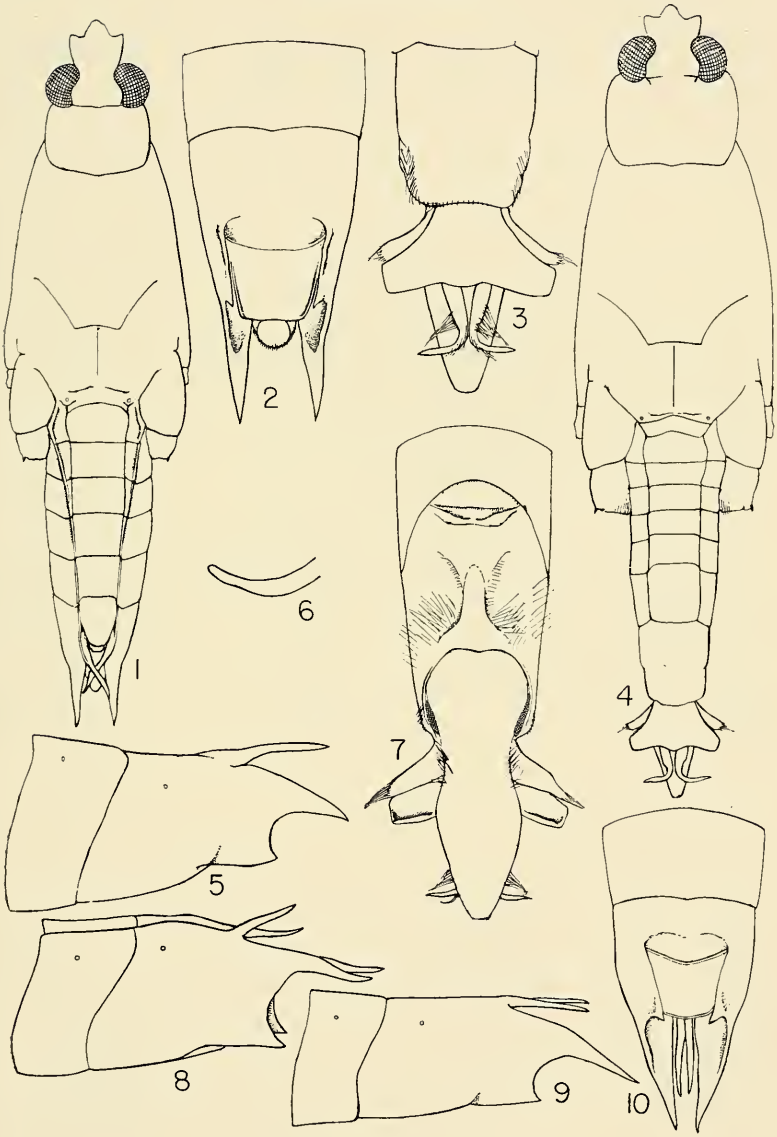


PLATE XXX

Ptilomera (*Ptilomera*) *dromas* Breddin

Showing that *Ptilomera argus* Breddin is a synonym and that the species occurs in Borneo as well as in Java.

FIG. 1. Female from West Borneo, dorsal view.

FIG. 2. Another female from the same place.

FIG. 3. Male type of *P. argus* Breddin.

FIG. 4. Female from Buitenzorg, Java.

FIG. 5. Male type of *P. argus* Breddin, dorsal view of genital segments.

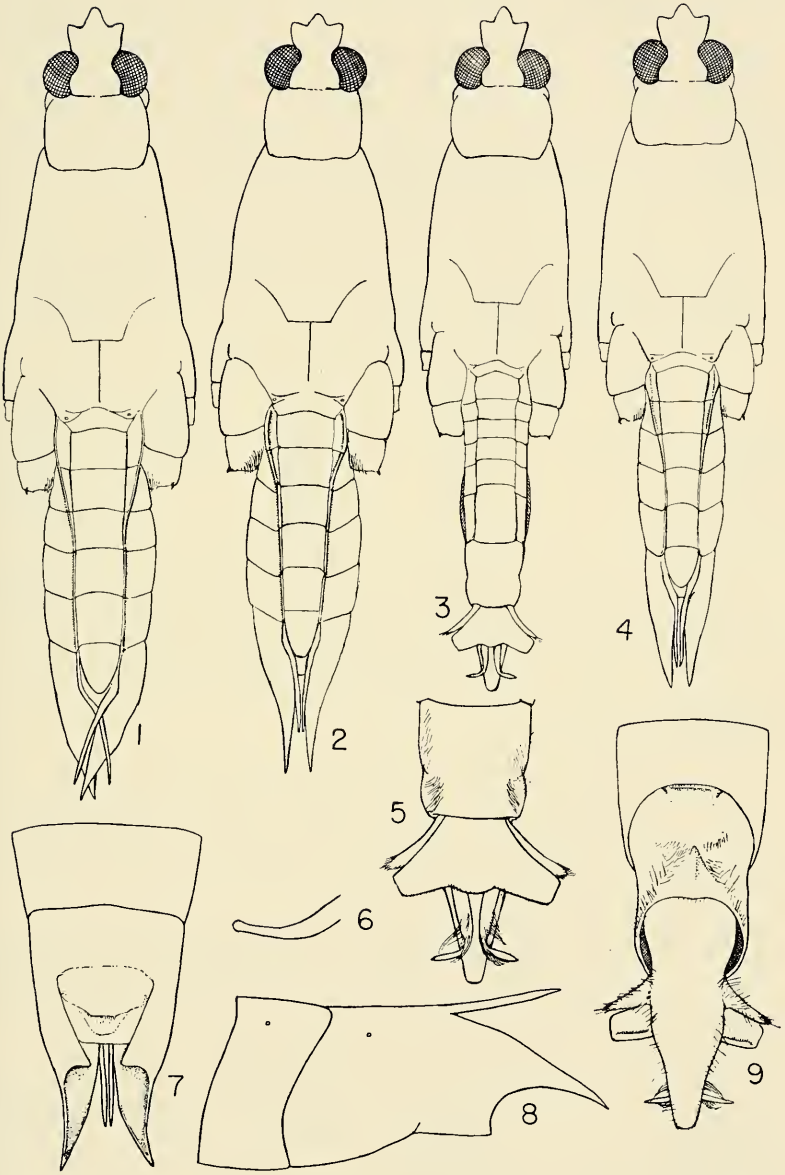
FIG. 6. Arm of left paramere of above seen in rear view.

FIG. 7. Female from West Borneo showing venter of sixth and seventh abdominal segments.

FIG. 8. Left side view of above.

FIG. 9. Male type of *P. argus* Breddin showing ventral view of genital segments.

PLATE XXX



Types of *Ptilomera dromas* Breddin

Size: Male type (apterous): Length 16.67 mm.; width of head 2.29 mm.; width of pronotum 2.67 mm.; length of mesonotum 3.71 mm.; greatest width of body across mesoacetabula 4.20 mm. Length of pregenital abdominal segments:Genital segments::93:84.

Female type (apterous): Length 15.24 mm.; width of head 2.10 mm.; width of pronotum 2.21 mm.; length of mesonotum 3.10 mm.; greatest width of body across mesoacetabula 4.00 mm. Length of thorax:Abdomen:123:161.

Color: Color and color pattern are typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male: 1st:2nd:3rd:4th::158:37: ?: ?.

Female: 1st:2nd:3rd:4th::138:30: ?: ?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male type	8.33 mm.	7.14 mm.	4.43 mm.	1.76 mm.
Female type	7.24 mm.	6.33 mm.	3.71 mm.	1.57 mm.

Middle leg	Femur	Hind leg	Femur
Male type	22.86 mm.	Male type	28.10 mm.
Female type	19.19 mm.	Female type	21.19 mm.

The male type of *P. dromas* has the seventh abdominal tergite plainly shorter than the three preceding segments together. Length of pregenital abdominal segments:Genital segments::93:84.

Female. Length of thorax:Abdomen::123:161. Seventh abdominal tergite as long as sixth.

Male type of *Ptilomera argus* Breddin (apterous)

Size: Length 14.05 mm.; width of head 1.95 mm.; width of pronotum 2.05 mm.; length of mesonotum 2.90 mm.; greatest width of body across mesoacetabula 3.14 mm.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments.

Male type: 1st:2nd:3rd:4th::120: ?: ?. The type has now only the first segment.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Front leg	6.75 mm.	5.60 mm.	2.95 mm.	1.30 mm.
Middle leg	17.38 mm.			
Hind leg	20.24 mm.			

The male type of *P. argus* has the seventh abdominal tergite nearly as long as the three preceding tergites together. We thought this character might separate *P. dromas* and *P. argus* but it proved to be variable. Length of pregenital abdominal segments:Genital segments::76:64.

Female type of *Ptilomera asbolus* Breddin (apterous)

Size: Length 17.19 mm.; width of head 2.05 mm.; width of pronotum 2.10 mm.; length of mesonotum 3.14 mm.; greatest width of body across mesoacetabula 3.71 mm. Length of thorax:Abdomen:: 117:145.

Color: Typical for the genus.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::127:30 ? : ?.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Front leg	6.90 mm.	5.71 mm.	4.10 mm.	1.52 mm.
Middle leg	17.62 mm.			
Hind leg	20.00 mm.			

Since none of the types has an entire antenna we give the comparative lengths of antennal segments of specimens in our collection that most closely resemble the types.

The one that resembles the type of *P. dromas:* male 1st:2nd:3rd:4th::170:37:53:35; female 140:31:44:31.

The one that resembles the type of *P. argus:* male 1st:2nd:3rd:4th::135:33:43:32; female 124:27:39:30. The above specimens came from the same place "Buitenzorg, Java." All three of these types have the following characteristics in common:

Male genital segments: Suranal plate with median lobe small, its lateral wings slightly surpassing median lobe; front and rear margins of lateral wings not parallel. Pygofer with its dorsolateral projections as seen from above short, apex of pygofer blunt. As seen from below pygofer not conspicuously broad beyond its middle; paramere with both shaft and arm rather stout.

Female. Length of thorax:Abdomen::118:149. Seventh tergite is nearly equal to sixth tergite in length. Connexival spines moderately long, arising from end of connexivum; dorsolateral lobe moderately long and spine-like, its upper margin from base of connexival spine to its tip much less than twice as long as upper connexival margin. With a ventrolateral lobe that is triangular; incis-

sion between dorsal and ventrolateral lobes broad and shallow; distal lobe of sternite of usual size and usually embraced by lateral lobes.

Comparative notes: This is the only species that occurs in Java. It was this slightly variable species and *P. pamphagus* Breddin complex of several species that made Dr. Lundblad believe that the taxonomy of this genus was quite hopeless.

Types: The types of *P. dromas, P. argus* and *P. asbolus* are all in the Breddin Collection of the Deutsches Entomologisches Institut in Berlin, Germany.

Distribution: Male and female types of *P. dromas* bear the label "Ost-Java Tengger Gebirg, H. Fruhstorfer." The male type of *P. argus* bears the label "Java occident. Sukabumi 2000' 1893, H. Fruhstorfer." The female type of *P. asbolus* bears the label "Java Foerster"; Breddin added Buitenzorg (Kraepelin). Beside the types we have seen the following apterous specimens:

Java: "Buitenzorg-Java, Apr. Dec. 96, D. G. Fairchild" 2 ♂ ♂, 4 ♀ ♀ (K. U. Torre-Bueno Coll.); 2 ♂ ♂, 2 ♀ ♀ bearing the same label we have marked "*P. argus* compared with type"; "Muller, Java" 3 ♂ ♂, 1 ♀ (K. U. Kirkaldy Coll.); "Goeneg Niseere, Dampang W. Java 3, 1926 Mrs. M. E. Walsh" 1 ♂, 3 ♀ ♀ (K. U.); "Java Fruhstorfer G. Severin" 1 ♀ (we labeled this *P. asbolus,* compared with type); "Giava, Sindana Java" 1 ♀ (K. U. Coll.); "Buitenzorg Java" 3 ♀ ♀ (K. U. Kirkaldy Coll.); "Java Dr. H. Bos" 1 ♀ (K. U. Kirkaldy Coll.); "Reinn Java" 1 ♀ (K. U. Kirkaldy Coll.); "C. N. Java Moeria Mts. 1939, Tjolo 20-24 X, M. A. Lieftinck" 1 ♂, 1 ♀ (K. U. Coll.); "Buitenzorg Java 3. 09 Bryant and Palmer Coll." 1 ♂ (K. U. Torre-Bueno Coll.); "Kediri, Java, 1 ♂ (K. U. Kirkaldy Coll.); "Buitenzorg, Java, 1919 W. C. V. Heurn" 1 ♂ 1 ♀ (Calif. Acad. Sci.).

The following were loaned to us for study by Dr. Wegner, Director of the Zoological Museum in Bogor: "W. Java 8-900 m. Tjikadjang, Bandjarwangi 7-10, IV, 1939. M. A. Lieftinck"; 2 ♂ ♂, 3 ♀ ♀; "C. N. Java 800 Moeria Mts. 1939 Tjolo 20-24 X, M. A. Lieftinck" 2 ♂ ♂, 5 ♀ ♀. "W. Java 500 m. G. Sanggaboeana 22 XII 1935 M. A. Lieftinck" 7 ♀ ♀; "W. Java 700 m. Bandoeng 19 VII 1940 J. Olthof" 1 ♂; "W. Java 700 m. Bandoeng 16 and 23 VI" 6 ♂ ♂, 6 ♀ ♀; "Palaboean ratoe 30 V 1932 Tjijolak, Lieftinck" 1 ♀; "W. Java 400-1000 m. Soekangegora II 1940" 1 ♀; "Wetar I-IV 1939 m. Lerai S. Bloembergen" 1 ♂.

The following is from Dr. E. Sutter, Museum of Natural History, Basel, Switzerland: "Ost Java, Lawang Djati Forests, Nglirip 200' M. E. Walsh" 1 ♂; "Ost Java, Lawang 1500' M. E. Walsh"

1 ♀ ; "West Java Wijnkoops Bay, M. E. Walsh" 1 ♂ , 1 ♀ ; "West Java, G. Molang 4290, M. E. Walsh" 1 ♂ , 1 ♀ ; "Nord Java, Japora Distr. M. E. Walsh" 1 ♂ "West Java Soekaboemi M. E. Walsh" 1 ♂ ; Borneo: "W. Borneo. Telok Ayer F. Muir" 2 ♂ ♂ 1 ♀ , all apterous (Calif. Acad. Sci.).

Ptilomera (*Ptilomera*) *werneri* Hungerford and Matsuda

Plate XXXI

1958. *Ptilomera werneri*, Hungerford and Matsuda, Bull. Brooklyn Ent. Soc. 53:70-73. 2 plates. (Described from the Philippines).

1960. *Ptilomera werneri*, Matsuda, Univ. of Kansas Sci. Bull. 41(2):267, 539. fig. 629.

This was the first species we described in this genus and its distinctive characters were so surprising that we were encouraged to undertake this revision of the genus. Our description of the species was entirely adequate but followed a somewhat different outline from the one used in this paper. The types have been returned to the Chicago Natural History Museum and we have only a male paratype now available.

Size: Male type (apterous): Length 10.9 mm. to 12.85 mm.; width of head 1.68 mm. to 1.93 mm.; greatest width of body across mesoacetabula 3.15 mm. to 3.78 mm.

Female type (apterous): Length 11.55 mm.; width of head 1.76 mm.; greatest width of body across mesoacetabula 3.36 mm.

Color: Reddish brown above, pale testaceous beneath. Head with two converging black lines between the eyes. Clypeus embrowned to black, antennae brownish black. Anterior margin of pronotum between the eyes black; front femur with two longitudinal blackish bands. Mesopleura with two black bands separated by a silvery pile. Middle and hind femora reddish brown, covered with short black setae; middle and hind tibiae darker.

Structural characteristics: Relative length of antennal segments.

Male holotype: 1st:2nd:3rd:4th::137:35:40:26.

Female allotype: 1st:2nd:3rd:4th::104:26:32:22.

Actual Lengths of Leg Segments

Front leg	Femur	Tibia	1st tarsal segment	2nd tarsal segment
Male paratype	7.04 mm.	6.42 mm.	3.31 mm.	1.30 mm.

Middle leg	Femur	Hind leg	Femur
Male paratype	20.5 mm.	Male paratype	27.1 mm.

Male. Length of pregenital abdominal segments:Genital segments::67:50. Middle femur heavily ciliated ventrally on distal

Ptilomera (*Ptilomera*) *werneri* Hungerford and Matsuda

FIG. 1. Male paratype, genital segments viewed from the right side showing the large bifurcate paramere.

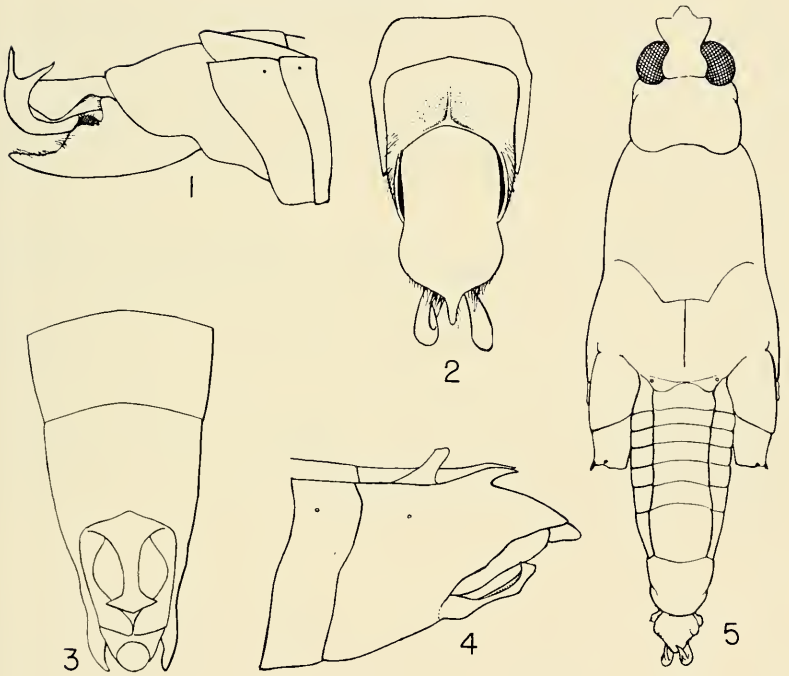
FIG. 2. Male paratype, genital segments as seen from below. Note the finger-like caudal projection of the pygofer.

FIG. 3. Female allotype, ventral view of caudal segments.

FIG. 4. Female allotype. Note the protuberance on the seventh tergite, the short connexival spines, the lack of a ventrolateral lobe on the seventh abdominal segments and the curious shape of the median caudal lobe of the seventh ventrite which is shown in Figure 3.

FIG. 5. Male paratype. Note the long median lobe of the suranal plate and the very small lateral wings. The first genital segment is much larger than the second.

PLATE XXXI



half, bare on basal half; tibia with adpressed hairs beneath. Middle and hind femora with many short black spicules above. Genital segments: Suranal plate, with median lobe broad at base but abnormally long, its tip rounded; lateral wings abnormally short. Pygofer unusually short, its dorsolateral projections directed dorsad, short and tips rounded. Dorsolateral margins of pygofer beyond dorsolateral projections parallel for a short distance and then steeply converging to form a finger like caudal tip of the pygofer. Paramere short, stout and bifurcate at distal end. First genital segment ventrally with a median longitudinal keel and with a depression on either side.

Female. Length of thorax: Abdomen::60:70. Seventh abdominal tergite plainly longer than the sixth, and with a dorsally directed protuberance on its rear margin. Connexival spines short and pointed, arising from end of connexivum. Dorsolateral lobe of seventh abdominal segment short, broad. Without ventrolateral lobe. Shape of distal median lobe of the seventh sternite as shown in Plate XXXI figs. 3, 4.

Comparative notes: This is the only known species with a bifurcated paramere in the male and the only known species with a protuberance on the seventh abdominal tergite in the female.

Types: Described from holotype, allotype and two male paratypes bearing the labels "Mountains w. of Lapulapu Iwahig Penal Colony, Palawan Isl. 2000 to 3000 ft. March 1-2, 1947," and C. N. H. M. Philippines Zool. Expeditions (1946-1947) F. G. Werner leg." The types are in the Chicago Natural History Museum except for the one male paratype in the Francis Huntington Snow Museum, K. U.

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* = synonym

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A Morphological Study of the Autonomic Nervous System of the Opossum, Didelphis Marsupialis

BY

LILY S. FENG
Department of Anatomy, University of Kansas, Lawrence, Kansas

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ABSTRACT: The general morphology of the autonomic nervous system of the opossum, as it is revealed by gross silver staining and dissection, is described in some detail. The thoracolumbar division arises from the last cervical vertebral level of the spinal cord cranially to the third or fourth lumbar vertebral level caudally, and is fundamentally similar in its morphology to that of other mammals. The cervical portions of the sympathetic trunks do not communicate with the vagi and communicate with the thoracic portions primarily by way of the ansa subclavia. The prevertebral ganglia of the abdominal region are poorly differentiated, one from another, and no definitive ganglion impar is recognizable.

The four cranial autonomic ganglia are similar to those in other mammals, except that the submaxillary ganglion is small and diffuse and is located immediately anterior to the common duct formed by the union of the submaxillary duct with the duct of the sublingual gland.

INTRODUCTION

In the past fifty or sixty years extensive morphological and physiological studies of the autonomic nervous system in certain mammals have been made by numerous investigators. A considerable

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amount of the information derived from these studies concerns the human being (Kuntz, 1953, 1958); literature concerning this system in other mammals such as the rhesus monkey (Kuntz, 1933), dog (Mizeres, 1955; Kuntz, 1958) and cat (Kuntz, 1953, 1958; Reighard and Jennings, 1961) is scattered and somewhat incomplete. Information on the autonomic nervous system in lower mammals is fragmentary, and the only study dealing with the system in the opossum appears to be that of Broek (1908), which deals primarily with the more obvious features of the sympathetic division as it is represented in the thoracic and lumbar regions.

In the absence of adequate study, it is rather commonly assumed that the autonomic nervous system is of similar morphological pattern in all mammals. Although the fundamental conservatism of the autonomic nervous system does provide a basis for such assumption, it would seem that differences of some interest might be found if certain of the relatively "primitive" mammalian forms were subjected to careful study. This study was initiated with the hope of supplementing the information on the autonomic nervous system in the opossum, and of comparing the system in that form with that of other better known forms.

I am deeply grateful to Dr. James Hall, formerly of the Department of Anatomy, University of Kansas, for initially suggesting and guiding the bulk of this study. I should also like to express my thanks to Dr. Irwin L. Baird for his assistance in the preparation of the manuscript, to Dr. E. Raymond Hall, Director of the Museum of Natural History at the University of Kansas, who has provided material for supplementary study, and to Miss Margaret Schumann for her help in preparation of the sections used for histological study.

MATERIALS AND METHODS

Ten specimens of *Didelphis marsupialis virginiana* were used in this investigation; four specimens were collected in the vicinity of Lawrence, Kansas, and the remainder were supplied by Quivira Specialties Company, Topeka, Kansas. All were adults; six were females, and four were males.

Prior to sacrifice, all specimens were kept on a diet of glucose and water for from thirty to thirty-seven days to mobilize peritoneal fat and thus facilitate dissection of nerve fibers (Richter, 1950). Following sacrifice by overdoses of pentobarbital sodium, specimens were perfused and fixed with ten percent formalin solution for at

least twenty-four hours. The abdominal and thoracic cavities were then opened and the specimens were treated with 0.75% silver nitrate solution for from eighteen to twenty-four hours at room temperature. In some cases, nerve fibers embedded in dense connective tissues were inadequately stained in this period and required local restaining to make fine nerve fibers visible. Dissections were, in all specimens, carried out with magnifications of from ten to thirty diameters provided by a stereoscopic dissecting microscope. Measurements were made directly with a scale in the case of larger structures, and with a calibrated ocular grid in the case of minute structures.

Short segments cut from selected levels of the spinal cord were fixed in Bouin's solution, embedded in paraffin blocks, sectioned at ten micra, mounted on slides and stained with Harris' alum hematoxylin. These served for analysis of the extent of the intermediolateral cell column.

THE THORACOLUMBAR DIVISION

As in most vertebrate animals, the thoracolumbar (sympathetic) division of the autonomic nervous system arises segmentally from thoracic and lumbar portions of the spinal cord by way of myelinated fibers called white or communicating rami. These fibers originate from small multipolar neurons of the intermediolateral cell column of the central gray matter of the spinal cord, and exit from the latter in the ventral roots of the spinal nerves. Although fibers were not actually traced, microscopic observation of sections of cervical, thoracic, lumbar and sacral portions of the spinal cord show that the intermediolateral cell column in the opossum extends from the seventh cervical vertebral level to the third or fourth lumbar level. It seems reasonable to assume, therefore, that sympathetic fibers are carried in roots of all segmental nerves from the last cervical level cephalically to the third or fourth lumbar level caudally. It is probable, however, that the contributions from the cervical and lowermost lumbar portions of the spinal cord are extremely limited, since the number of cells comprising the intermediolateral cell column is small in these regions.

The fibers from the intermediolateral cell column accompany the spinal nerve through the intervertebral foramen, then leave the nerve and join one of the two longitudinal paravertebral sympathetic trunks. The latter extend along the ventrolateral aspects of

the vertebral column from the base of the skull to the sacral region. Each trunk is composed of a series of interconnected, irregular, angular or fusiform ganglia composed of aggregates of multipolar neurons with variable numbers of dendritic processes. The number or size of these ganglia is not regular or uniform in pattern, even in the two trunks of one animal; by actual comparative counting and observation in the ten animals investigated, the number of ganglia varied from six to ten in the thoracic region, four to six in the lumbar region and only one or two small swellings were visible in the sacral region.

The neurons of the intermediolateral cell column are called preganglionic neurons and their fibers are accordingly designated preganglionic fibers. After traversing the communicating rami and joining the sympathetic trunks, preganglionic fibers may synapse with multipolar neurons in the ganglion of the same segment or continue for a distance cephalad or caudad in the sympathetic trunk before synapsing with ganglionic neurons in one of the paravertebral or prevertebral ganglia. Axons of the ganglionic neurons extend peripherally to the structures innervated by the sympathetic nervous system and are termed postganglionic fibers.

Situated behind the parietal pleura, the sympathetic trunks in the thoracic region begin at the level of the first rib and extend caudally along the ventral surfaces of the transverse processes of the thoracic vertebrae. At the level of the eleventh or twelfth thoracic vertebra, the sympathetic trunks turn slightly medially and ventrally onto the vertebral centra before leaving the thorax through the crura of the diaphragm.

Each thoracic sympathetic trunk (fig. 1) includes seven to ten interconnected ganglia which, except for the first and the second ganglia, are segmentally arranged from the fourth to the tenth or eleventh thoracic vertebra. The first ganglion of the thoracic series is fusiform and is the largest of the paravertebral ganglia; it lies diagonally upon the head of the first rib in most cases, but sometimes extends caudally to the level of the second rib. It appears to consist of a fusion of the first thoracic and the caudalmost cervical sympathetic ganglion and thus may be properly termed a stellate ganglion as defined by Kuntz (1953). The second ganglion, considerably smaller than the stellate, is usually found at the level of the third or fourth rib. The remainder of the thoracic ganglia are segmentally arranged and are located ventral to the necks of the

ribs. Each ganglion of the thoracic sympathetic trunk is connected with its corresponding spinal nerve by one or occasionally two communicating rami.

From the medial aspect of the sympathetic ganglia and interganglionic portions of the thoracic sympathetic trunks, numbers of slender preganglionic and postganglionic fibers arise to form the thoracic cardiac and splanchnic nerves, or pass ventrally into one of the subordinate thoracic sympathetic plexuses. Some contribute to the formation of the pulmonary plexuses and the plexus on the descending aorta.

Cephalically, the thoracic sympathetic trunk is continuous with the cervical sympathetic trunk at the medial aspect of the cranial pole of the stellate ganglion (figs. 2, 3, 4). From this point a relatively small bundle of fibers courses cephalically, passes dorsal to the subclavian artery and extends into the neck along a course similar to that normally followed by the main cranial extension of the sympathetic trunk in man. Just medial to the point where this bundle springs from the ganglion, a significantly larger bundle arise, passes ventral to the subclavian artery and dorsal to the innominate vein and joins the dorsal branch just cranial to these vessels. The loop formed by this large ventral limb is recognized as the ansa subclavia. From it fine filaments arise and follow the subclavian artery as the subclavian plexus.

From the left ansa subclavia, ventral to the subclavian artery, one to two cervical cardiac nerves arise. These soon divide into numbers of delicate filaments which travel from the base of the subclavian artery to the ventral surface of the aortic arch where they enter into the formation of a network, the superfician or ventral cardiac plexus (figs. 2, 3). Another cardiac nerve descends from the medial aspect of the caudal pole of the left stellate ganglion to the ventral surface of the aortic arch where it too breaks into filaments and joins the cardiac plexus. On the right side (fig. 4) a cardiac nerve derived from the caudal cervical ganglion (see below), or from the trunk below it, descends along the right common carotid artery to the base of the neck, where it bifurcates into two branches. The uppermost of these subdivides into many fine fibers, most of which join the ventral cardiac plexus; a few pass to the dorsal surface of the aortic arch. The lower right cervical cardiac nerve breaks down into a network which courses along the dorsal part of the superior vena cava to the dorsal surface of the aortic

arch and the ventricular wall where it joins the branches of the upper right cervical cardiac smypathetic nerve in the formation of the deepor dorsal cardiac plexus. No cardiac fibers arise from either thoracic sympathetic trunk below the level of the stellate ganglion. The ventral and dorsal cardiac plexuses communicate freely and are actually a continuous network; they are arbitrarily recognized on the basis of their positions relative to the arch of the aorta.

The cardiac plexuses are the main source of the left and right pulmonary plexuses and the two coronary plexuses (figs. 3, 4). The left plumonary plexus is a small network formed largely by extension of the ventral cardiac plexus onto the left pulmonary artery. To this, a few filaments derived from the caudal end of the stellate ganglion, from the left thoracic sympathetic trunk of the second to fourth vertebral levels and from the dorsal cardiac plexus are added. The right pulmonary plexus is chiefly an extension of the dorsal cardiac plexus; there appears to be no contribution of fibers from the right thoracic sympathetic trunk below the stellate ganglion.

In a similar fashion, the left coronary plexus, which follows the left coronary artery, is formed primarily by filaments from the ventral cardiac plexus with some contributions from the dorsal cardiac plexus. The right coronary plexus is formed by filaments from the dorsal cardiac plexus and a few fibers from the ventral cardiac plexus; it courses along the right pulmonary artery.

Below the stellate ganglion, several delicate filaments arise from each thoracic sympathetic trunk and follow the intercostal arteries to the dorsal aorta. Here, with filaments from the opposite side, they form the aortic plexus (fig. 1), a sparse network which extends caudally along the aorta. Some of these filaments especially those in relation to the lower half of the esophagus, extend or send branches to the esophagus where they form the inconspicuous esophageal sympathetic plexus. This plexus also receives one or two fine filaments from the cardiac sympathetic nerves which arise from the ansa subclavia.

From the level of the tenth to the thirteenth thoracic vertebra, each thoracic sympathetic trunk gives rise to three branches considerably larger than the thoracic cardiac nerves; these are the thoracic splanchnic nerves (fig. 1). The most cephalic one, the greater splanchnic nerve, is the largest and usually arises by a single root from the ganglion or interganglionic portion of the trunk at the tenth or eleventh (in one case, ninth) vertebral level. The second branch, the lesser splanchnic nerve, is slightly smaller than the

greater splanchnic nerve and is derived by a single root from the twelfth or thirteenth vertebral level of the thoracic sympathetic trunk. The third or least splanchnic nerve arises a few millimeters below the origin of the lesser splanchnic nerve. More variable than the other two, it originates at either the thirteenth thoracic or first lumbar vertebral level, or from the trunk between them. In some cases, the nerve has but a single root; in others, it arises from one main root which is supplemented by smaller rootlets from adjacent portions of the trunk.

Along each splanchnic nerve, especially the greater and lesser, ganglion-like swellings are often observed. Similar structures are described in man and cat (Kuntz, 1956) and are designated as ganglia included in the splanchnic nerves. The splanchnic nerves are, in most cases, unilaterally interconnected by branches and they frequently divide and/or combine in (apparently) a completely inconsistent manner before leaving the thorax by piercing the crus of the diaphragm.

From its origin anterior to the subclavian artery at the junction of the ansa subclavia and the more dorsal sympathetic trunk, the cervical sympathetic trunk extends cephalically, in the groove between the trachea and the esophagus, along the ventral surface of the transverse processes of the seventh to the second cervical vertebra and is separated from the latter by the longus capitis and the longus collimuscles. At its origin, the cervical sympathetic trunk lies lateral and dorsal to the carotid artery and the vagus nerve. Almost immediately after its origin it turns medially and dorsally and, throughout the remainder of its course, each cervical sympathetic trunk maintains a position immediately dorsal to the carotid artery and medial to the vagus nerve and jugular vein. Each trunk is enclosed in a heavy sheath of connective tissue which is tightly bound to the connective tissue enclosing the carotid artery, jugular vein and vagus nerve.

Unlike the arrangement seen in the thoracic region, no communicating rami were found to connect the cervical sympathetic trunk with the cervical spinal nerves. Communicating rami to the last five cervical spinal nerves of each side arise from the cranial pole of the corresponding stellate ganglion. That to the last cervical spinal nerve arises individually from the lateral side of the cranial end of the stellate ganglion; communicating rami to the fourth, fifth, sixth and seventh cervical spinal nerves arise as branches from a

large common trunk from the cranial pole of the stellate ganglion (figs. 2, 3, 4). The rami to the posterior cervical nerves are considerably larger than those to the more anterior nerves; the ramus to the last cervical spinal nerve is reasonably large and well-defined but, anterior to this, each communicating ramus is found to be progressively smaller until, at the fourth cervical spinal nerve, only a delicate filament connects with the sympathetic nervous system. No communicating rami to the first, second and third cervical spinal nerves were found in any of the specimens dissected.

The three ganglia present on each cervical sympathetic trunk (figs. 2, 3, 4) are not segmentally arranged as are those in the thoracic region. The most cephalic of these, the cranial cervical sympathetic ganglion, is fusiform, is five or six millimeters in length and is situated dorsomedial to the carotid artery just caudal to the bifurcation of that vessel; the vagus nerve is contiguous with the lateral margin of the cranial cervical sympathetic ganglion. From the cranial end of this ganglion, four or five large branches arise, pass to the internal carotid artery and follow it into the skull. These branches constitute the origin of the carotid sympathetic plexus. This plexus extends as a heavy network along the carotid arteries and is the only apparent source of sympathetic innervation in the head region. A few millimeters caudal to the foramen lacerum a small bundle of nerve fibers leaves the carotid plexus as the (great) deep petrosal nerve and immediately joins the great superficial petrosal nerve (which originates at the geniculate ganglion of the facial nerve and is embedded in a groove on the dorsal surface of the sphenoid bone) to form the nerve of pterygoid canal (Vidian nerve). The latter proceeds forward through the pterygoid canal, traverses the inferior orbital fissure and enters the sphenopalatine fossa to terminate at the sphenopalatine ganglion (see below). The remainder of the carotid plexus continues forward into the skull with the internal carotid artery. Fine networks of filaments follow each branch of the carotid artery, but could not be traced for significant distances along these branches.

Although an intensive study of the sympathetic innervation of the head was not conducted, the above observations on cranial sympathetic distribution in the opossum disclose no major differences from conditions described in the cat (Reighard and Jennings, 1961) and man (Kuntz, 1953). It seems reasonable to assume that the whole pattern of sympathetic distribution in the head region of the opossum may be much like that in cat and in man.

The second ganglion, the middle cervical sympathetic ganglion (figs. 2, 3, 4) is a slender spindle-shaped body approximately twice as thick as the interganglionic trunk and is situated midway between the stellate and cranial cervical sympathetic ganglion. The third ganglion is merely a slight swelling of the cervical sympathetic trunk immediately anterior to its origin. Since it corresponds in position to the caudal cranial sympathetic ganglion of the dog (Mizeres, 1955), it seems logical that this ganglion be recognized by that name. In some specimens, this ganglion appeared to be absent on one side, but in none of the specimens was it missing bilaterally.

The sympathetic trunks in the lumbar region (fig. 5) are direct continuations of those in the thoracic region. Caudal to their entries into the abdominal cavity through the crura of the diaphragm dorsal to the thoracic splanchnic nerves, the trunks incline medially and course caudally, adjacent to the dorsal aorta and partially under the cover of the psoas muscles. As they approach the sacral region, the lumbar sympathetic trunks pass dorsal to the aorta, approach the midline and diminish in size; here they become interconnected by delicate filaments. Each trunk exhibits four or five ganglia which are relatively flatter than those of the thoracic region and are irregular in size and in shape. As in the thoracic region, each lumbar sympathetic trunk is connected with the lumbar spinal nerves by communicating rami.

Medially, each ganglion of the lumbar sympathetic trunk gives rise to several fine branches, lumbar splanchnic nerves (fig. 5), which contribute to either prevertebral ganglia or plexuses in the abdominal cavity. The interganglionic portions of the trunk also give off a few fine filaments which tend to follow the same distribution as the splanchnic nerves from the ganglia or combine with them a short distance from the trunk. The splanchnic nerves from the first lumbar sympathetic ganglion contribute chiefly to the celiac ganglionic complex (see below), but some filaments are directed to the cranial mesenteric ganglion (see below). Frequently, the splanchnic nerves from the first lumbar sympathetic ganglion unite with the descending thoracic splanchnic nerves prior to their termination in the celiac ganglionic complex. Lumbar splanchnic nerves from the second ganglion end partly in the cranial mesenteric ganglion, but most of them contribute to the intermediate mesenteric or the aortic plexus (see below) on the ventral surface of the abdominal aorta; the latter filaments are supplemented by splanchnic

nerves from the third ganglion and some from the fourth ganglion. The majority of the splanchnic nerves from the fourth ganglion terminate chiefly in the caudal mesenteric ganglion (see below), which is located in the mesentery anterior to the bifurcation of the aorta. Splanchnic filaments from the fifth lumbar ganglion follow the hypogastric artery to enter into the formation of a plexus of the same name (see below).

The major prevertebral ganglia of the abdominal region (fig. 5) are the celiac, cranial mesenteric, intermediate mesenteric and the caudal mesenteric ganglia. From these ganglia, numerous fine filaments arise and form extensive prevertebral plexuses. The bilateral celiac ganglia are large, complex, flattened structures of irregular shape and are located in an area bounded by the common trunk of the celiac artery, the cranial mesenteric artery, the renal arteries, and the aorta. Each celiac ganglion is arbitrarily separable into a number of smaller ganglia. At the origin of the renal artery, a small star-shaped gangliform mass is loosely attached to the anterolateral side of the celiac ganglion and may be designated as the aorticorenal ganglion; from this, filaments arise and constitute the main source of the renal plexuses along the renal arteries. Caudally, each celiac ganglion is extended and, on the ventral surface of the aorta posterior to the common trunk of the celiac and cranial mesenteric arteries, this extension fuses with that of the opposite side to form the irregular cranial mesenteric ganglion. It must be emphasized that recognition of these three ganglia in the opossum is rather arbitrary since they appear as one continuous structure which surrounds the common trunk of the celiac and cranial mesenteric arteries dorsally and posterolaterally as a semicircular band.

From the cranial end of each celiac ganglion, a few filaments arise and, as the delicate phrenic plexus, follow the phrenic artery to the diaphragm. Several fibers arise from the lateral side of each celiac ganglion adjacent to the renal artery and join fibers from the aorticorenal ganglion to form the renal plexus. This plexus courses along the renal artery as a delicate network and enters the kidney. At the hilus of that organ, a few fine filaments leave the renal plexus and follow the ureteric artery and ureter to the dorsal surface of the bladder. From the ventral surface and anterolateral margin of each celiac ganglion, numerous fibers pass directly to the adrenal gland as the adrenal plexus; these accompany the artery to the adrenal gland, which is located medial to the cephalic end of the kidney. On the right side, the adrenal gland is often attached to the

tip of the right lobe of the liver and to the portal vein by dense connective tissue; through this some filaments of the adrenal plexus pass to the portal vein and follow the latter to the liver.

The celiac and cranial mesenteric arteries in the opossum originate from a common trunk which divides into two branches (fig. 5). One branch turns to the left as the splenic artery, which gives rise to a common stem for the left gastric and the left phrenic arteries a short distance from its origin, then courses through the body and tail of the pancreas to the spleen and greater curvature of the stomach. The second branch of the original trunk gives rise to the hepatic artery and its branches (gastroduodenal and pancreatic arteries), to the crainial mesenteric artery and to a descending caudal mesenteric artery. The right celiac ganglion contributes fibers primarily to the formation of the hepatic plexus and a few fibers to the cranial mesenteric plexus. The hepatic plexus is a moderately dense network which courses along the artery and its branches to reach the liver, gall bladder, head of the pancreas, lesser curvature of the stomach and duodenum. Additionally, the right celiac ganglion contributes a few fibers to the cranial mesenteric plexus (see below).

The left celiac ganglion contributes heavily to the formation of the splenic plexus, which follows the splenic artery and its branches to the spleen, to the body and the tail of the pancreas and to the greater and lesser curvatures of the stomach. Several fibers leave the caudal margin of the left celiac ganglion and contribute to the cranial mesenteric plexus. Although direct connections between the two celiac ganglia are not obvious, fine fibers from both sides do mingle in a network at the bases of the cranial mesenteric and hepatic arteries.

The cranial mesenteric ganglion (fig. 5) is a semilunar band which connects the slender posterior ends of the celiac ganglia and is situated on the ventral surface of the aorta immediately posterior to the common trunk of the celiac and cranial mesenteric arteries. This ganglion is the main source of the cranial mesenteric plexus, a dense network of relatively course fibers associated with the cranial mesenteric artery. As noted above, a few fibers from each celiac ganglion descend and contribute to the plexus near its origin. A large portion of the cranial mesenteric plexus follows the main artery and its branches in their distribution to the jejunum, ileum, and cecal region of the colon. The remainder of the plexus follows the caudal mesenteric artery to the greater part of the colon and to the

rectum. A few fibers arise from the cranial mesenteric ganglion and enter the right and left renal plexuses, and several course fibers arising from the caudal end of the ganglion contribute to the formation of the intermediate mesenteric plexus. The latter is a rather dense network containing several scattered ganglia and long heavy parallel bundles of fibers which extend between the cranial and caudal mesenteric ganglia (see below). This plexus is located on the ventral surface of the aorta and extends from the caudal end of the celiac ganglionic complex to the bifurcation of the aorta. At the origins of the gonadal arteries the plexus contains the small paired gonadal ganglia. Each of these is connected anteriorly with the intermediate mesenteric plexus by a large bundle of fibers and posteriorly with the caudal mesenteric ganglion by a few delicate filaments; each also receives several fine fibers from the third lumbar splanchnic nerve. Filaments from the gonadal ganglia, supplemented by a few fibers directly from the intermediate mesenteric plexus, form the gonadal plexuses, which accompany the arteries to the gonads. These plexuses also receive contributions from the ureteric plexuses as they descend.

At the bifurcation of the aorta, the intermediate mesenteric plexus gives rise to two sets of fibers; each of these follows a common iliac artery and its branches and, on each side, the major part of these fibers accompanies the hypogastric artery as the hypogastric plexus (fig. 5). The latter passes posteriorly to the side of the rectum and region of the neck of the bladder in the male, and to the side of the rectum and vagina in the female. The hypogastric plexuses are the main sources for the formation of the pelvic plexuses, which are provided with supplementary contributions of fibers from the sacral sympathetic trunks and sacral spinal nerves at the first and second sacral vertebral levels (figs. 6, 7). The pelvic plexuses are tightly packed networks situated ventrolateral to the rectum. Each has a large irregular pelvic ganglion in its center and, in some specimens, several tiny ganglia are found scattered in the plexus near the neck of the urinary bladder. These plexuses give rise to a number of poorly-defined subordinate plexuses named according to the organs they innervate. These pass ventrally to the urinary bladder, prostate gland and urethra in the male (fig. 6), and to the urinary bladder, uterus and vagina in the female (fig. 7).

Just caudal to the level of origin of the gonadal arteries, approximately twenty millimeters anterior to the bifurcation of the aorta, the intermediate mesenteric plexus sends a few fibers into the root

of the mesentery; these pass to the caudal mesenteric ganglion (fig. 5), an irregular, flattened, bilobed structure approximately twice as large as the gonadal ganglion. It is located within the mesentery ventral to the aorta and to the right of the mid-sagittal plane. Anteriorly, this ganglion receives a few long bundles of fibers from the celiac ganglionic complex and, dorsally or laterally, it receives the splanchnic nerves of the fourth lumbar ganglion. From the caudal mesenteric ganglion, a relatively large trunk passes to the gonadal ganglion of each side. A few fibers leave the caudal end of ganglion and pass to the gonadal artery of each side to supplement the gonadal plexuses. In addition, the caudal mesenteric ganglion gives off fibers which course through the mesentery to the caudal mesenteric artery and, by following the latter, reach the descending colon and the rectum.

THE CRANIOSACRAL DIVISION

The craniosacral or parasympathetic division of the autonomic system arises from two discontinuous regions, the cranial and the sacral portions of the central nervous system. The functions of this division have been clearly shown to be antagonistic to those of the thoracolumbar division in various viscera of different animals (Babkin, 1946). The cranial portion is derived from certain nuclei located in the gray matter of the midbrain and brain stem and composed of preganglionic parasympathetic neurons. From these neurons, preganglionic fibers pass peripherally in the third, seventh, ninth, and tenth cranial nerves to one of four cranial parsympathetic ganglia (ciliary, sphenopalatine, submaxillary, or otic ganglion) or to one of the numerous small ganglia in the walls of the structures innervated. In these ganglia, the preganglionic fibers make their synapses with ganglionic neurons and these, in turn, send postganglionic fibers to the effectors. The sacral portion arises from the medial autonomic nuclei of the gray matter of the spinal cord in the sacral and, probably, lowermost lumbar regions. As preganglionic fibers, axons from cells of these nuclei proceed in part as pelvic nerves to the pelvic ganglion where they synapse with neurons which send postganglionic fibers peripherally. Other preganglionic fibers pass directly to certain of the pelvic viscera and there synapse with small intramural ganglia.

Preganglionic parasympathetic fibers in the cranial region are impossible to trace, since they are incorporated into the cranial nerves. The four cranial parasympathetic ganglia are, however, identifiable

in all specimens, and sufficient of their connections are visible to permit extrapolations concerning sources and courses of parasympathetic fibers.

Ciliary ganglion: The rostralmost cranial autonomic ganglion is the ciliary ganglion, a tiny fusiform structure approximately one millimeter in length and one and one half millimeters in width (fig. 8). It is located to the lateral side of the optic nerve, between that structure and the tendons of the inferior rectus and lateral rectus muscles, and lies about eight millimeters from the optic foramen. According to Kuntz (1953), this ganglion is ontogenetically related to the oculomotor and ophthalmic nerves. As in the cat (Reighard and Jennings, 1961) this ganglion in the opossum is attached to the inferior division of the oculomotor nerve by the short ciliary root, a bundle of preganglionic fibers from the ipsilateral Edinger-Westphal nucleus; some of these fibers merely course through the ganglion but most of them synapse in the ganglion. On its upper border, the ciliary ganglion receives, as the long ciliary root, a few fine filaments from the ophthalmic branch of the trigeminal nerve; these fibers are probably sensory and originate from neurons of the semilunar ganglion. This differs greatly from that in the cat (Christensen, 1936). In company with the long and short roots, some postganglionic sympathetic fibers from the internal carotid and cavernous plexuses probably reach and traverse the ciliary ganglion. Two to five fine filaments from the cranial end of the ciliary ganglion extend along the optic nerve as the short ciliary nerves and enter the posterior surface of the eyeball.

Sphenopalatine ganglion: The sphenopalatine ganglion (fig. 9) is the largest cranial parasympathetic ganglion. It is a flattened fusiform structure two millimeters in width and six millimeters in length, and is situated in the external pterygoid fossa approximately six millimeters caudal to the sphenopalatine foramen. Medially, this ganglion is in intimate contact with the pterygoid bone; laterally it is covered by the inferior rectus muscle and is adjacent to the infraorbital branch of the maxillary nerve. Three or four short (sensory) fibers arise from the latter and enter the lower margin of the ganglion. Posteriorly, the sphenopalatine ganglion receives the nerve of the pterygoid canal. The latter is formed by the great superficial petrosal nerve (from the facial nerve), which proceeds anteriorly in a groove on the dorsal surface of the sphenoid bone and, a few millimeters posterior to the foramen lacerum, unites with

the deep petrosal nerve (see above). From this union, the nerve traverses the pterygoid canal and enters the caudal margin of the ganglion as a large trunk.

From the anterior tip of the ganglion, a large trunk springs out and splits immediately into two branches, the posterior nasal nerves, which course through the sphenopalatine foramen to the nasal cavity, to the sinuses, and to the hard palate. Just caudal to the origin of the above nerves, a smaller branch arises from the upper margin of the ganglion as the major or great palatine nerve to the hard palate. From the medial surface and the inferolateral margin of the ganglion, two or three fine filaments course to the soft palate as the minor or small palatine nerves by traversing the lesser or accessory palatine foramina. From the upper border of the sphenopalatine ganglion, a small bundle of fibers arises near the anterior limit and travels upward to the lacrimal gland. A few filaments from the posterior end of the ganglion follow the ethmoidal branch of the ophthalmic artery to the ethmoidal air cells.

Submaxillary ganglion: In the opossum, the sublingual and submaxillary glands are located together at the posterior border of the masseter muscle below the parotid gland and lie at the junction of the lower jaw and anterior neck. The duct of each gland extends forward a few millimeters from the anterior border of the gland; the two then join to form a common duct which pierces the digastric and mylohyoid muscles to reach the mouth. This duct courses a few millimeters below the lingual branch of the mandibular nerve.

The submaxillary ganglion (fig. 10), an irregular structure less than one millimeter in diameter, is situated ventral to the submaxillary duct immediately posterior to its union with the duct of the sublingual gland; in some cases, the ganglion is related to the union itself or to the posterior part of the common duct. Anteriorly, this ganglion receives fine filaments which descend to the common duct from the lingual nerve directly above, then travel posteriorly for some distance along the duct to reach the submaxillary ganglion. Filaments leave the ganglion posteriorly and medially to enter the adjacent salivary glands.

Otic ganglion: The otic ganglion (fig. 11) is a flattened, minute structure (in some cases, it is bilobed) approximately one and one-half millimeters in length; it is located medial to the anterior branch of the mandibular nerve immediately below the foramen ovale. The ganglion is in contact anteriorly with the posterior margin of the

internal pterygoid muscle and posteriorly with the tensor veli palatini muscle. Caudally, the otic ganglion receives a small bundle of fibers from the glossopharyngeal nerve; anteriorly it is connected with a branch from the anterior division of the mandibular nerve, which innervates the internal ptrygoid muscle and the nerve of the pterygoid canal by two fine filaments. From the ventral border of the ganglion, three or four delicate filaments are sent to the tensor veli palatini muscle, which separates the ganglion from the auditory tube. Laterally, the otic ganglion gives off two fine branches; one enters the mandibular nerve next to the ganglion the other follows an artery to the parotid gland. No contribution to the auriculotemporal nerve can be found.

Vagus nerve: The course of the vagus nerve in the opossum (figs. 1, 3, 4) is similar to that described in the cat (Reighard & Jennings, 1961). Each vagus nerve exists from the skull through the jugular foramen, then, as a large trunk, descends lateral to the trachea to the point of bifurcation of the latter. It follows the esophagus through the diaphragm and enters into the formation of the celiac and other subordinate plexuses in the abdominal cavity. From the vagus nerve, numerous branches arise at various levels of its course and enter into the autonomic plexuses above the diaphragm.

In the cervical region, the courses of the two vagi are virtually identical. Immediately below the jugular foramen, lies the nodose ganglion, which is ovoid, approximately seven or eight millimeters in length, and situated in the carotid sheath anterolateral to the cranial sympathetic ganglion and carotid artery. From the medial margin of the caudal part of this ganglion, the cranial laryngeal nerve arises and crosses ventral to the cranial sympathetic ganglion and carotid artery in its course to the larynx. As it crosses the artery, the laryngeal nerve gives off a cardiac nerve (figs. 3, 4), which first courses posteriorly along the ventral surface of the common carotid artery; approximately midway down the neck the cardiac nerve passes to the dorsal surface of the same artery and courses posteriorly to the arch of the aorta. There it breaks into numerous delicate filaments which enter the dorsal cardiac plexus together with the filaments of the same nerve of the opposite side.

Beyond the origin of the cranial laryngeal nerve, the vagus nerve courses posteriorly for a short distance, then turns somewhat medially to lie laterally adjacent to the carotid artery and ventral to the cervical sympathetic trunk. It maintains these relationships

in the rest of its course in the cervical region, but becomes more superficial as it approaches the base of the neck. Beyond the origins of the common carotid arteries the courses and distribution of the two vagi differ.

At the base of the neck the left vagus nerve proceeds posteriorly, between the left common carotid and left subclavian arteries, first on the ventral surface of the arch of the aorta, then courses dorsal to the left innominate vein, pulmonary vessels and the left bronchus. Beyond this level, the nerve continues posteriorly on the ventral surface of the esophagus and enters the abdominal cavity with that structure. Immediately caudal to the diaphragm, the left vagus nerve breaks down into numerous branches; most of these enter the splenic and gastric plexuses along the arteries of the same names; the rest enter the cranial end of the left celiac ganglion.

Several branches arise from the thoracic portion of the left vagus nerve. Immediately below the arch of the aorta, it gives off a relatively large branch, the recurrent laryngeal nerve, which turns craniad, dorsal to the arch, and courses anteriorly adjacent to the trachea. In this portion of its course, the recurrent nerve sends several small branches to the dorsal surface of the trachea and to the esophagus. Approximately five millimeters caudal to the larynx, the recurrent laryngeal nerve branches into five to seven fine filaments which enter the larynx separately. Caudal to the origin of the recurrent laryngeal nerve, the left vagus nerve gives rise to four or five fine fibers; two or three of these enter the dorsal and ventral cardiac plexuses; the other two course to the ventral surface of the left pulmonary artery and bronchus to enter the left pulmonary plexus. Beyond the pulmonary root, the left vagus nerve also gives off several fine filaments which join the esophageal plexus.

The course of the right vagus nerve through the thoracic cavity differs somewhat from that of the left vagus nerve. It passes ventral to the right subclavian artery, dorsal to the right innominate vein, right bronchus and pulmonary vessels. Beyond the root of the lung, the right vagus nerve courses posteriorly on the dorsal surface of the esophagus and follows the latter into the abdominal cavity. After entering the abdominal cavity, the right vagus nerve, like the left, branches into numerous fine fibers. The majority of these contribute to the hepatic and mesenteric plexuses related to the arteries of the same names, but a small part of the fibers enters the anterior margin of the right celiac ganglion. The right vagus nerve gives off a recurrent laryngeal nerve immediately caudal to the right

subclavian artery and passes anterolaterally adjacent to the trachea. The light recurrent laryngeal nerve, like the left, branches into several fine filaments shortly before its entrance into the larynx. Caudal to the origin of the recurrent nerve, the right vagus nerve gives off one or two fine filaments which follow the right subclavian artery and the right innominate vein to the arch of the aorta and enter the dorsal and ventral cardiac plexuses. Dorsal to the right pulmonary root, two fine filaments arise from the right vagus, spiral ventrally around the bronchus and pulmonary vessels and join the right pulmonary plexus. On the right dorsal surface of the esophagus, several delicate filaments arise from the right vagus nerve and contribute to the dorsal part of the esophagus plexus.

The sacral portion of the craniosacral division of the autonomic nervous system is comprised solely of the fibers originating from certain of the medial parasympathetic nuclei of the spinal cord; these fibers exit from the cord in company with the first and second sacral nerves. Shortly after the sacral nerves are outside of the spinal canal, these fibers diverge as two or three small bundles, the pelvic nerves, which proceed to the pelvic ganglia on either side of the rectum. From the pelvic ganglia, numerous delicate filaments arise and mingle with sympathetic fibers in the pelvic plexus and its subordinate parts.

DISCUSSION

Although knowledge of the autonomic nervous system has been derived mainly from the study of mammals, fragmentary information concerning this system in lower chordates reveals that the autonomic nervous system is, phylogenetically, a rather primitive system. It can be traced as a diffuse enteric network, apparently independent of the central nervous system, in the regions of the heart, pharynx and gut in the balanglossids or acorn worms, chordates presumed to be not far removed from early chordate stem stock (Bullock, 1945; Dawydoff, 1948; cited by Nicol, 1952; Boeke, 1949). In *Amphioxus* visceral fibers are found in the dorsal roots of the segmental spinal nerves; in forms more advanced than this, visceral fibers occur in both dorsal and ventral roots of the spinal nerves. This tends to indicate that the visceral network is the primitive basis of the autonomic nervous system, and that its connection with the central nervous system is secondary.

Within the chordates, the autonomic nervous system shows additional evidence of progressive elaboration of complexity in mor-

phology and physiology, and some indications of diversification of organization and specialization are clearly shown. In the essentially brainless *Amphioxus* there is no parasympathetic system; visceral fibers in the dorsal roots of the spinal nerves reach the gut, gill pouches and other visceral structures after traversing the dorsal body wall (Goodrich, 1958). In cyclostomes early representation of both sympathetic and parasympathetic innervation of the viscera is present. The cardiac plexus is composed solely of contributions from the vagus nerve, but the latter has no functional effect on cardiac activity. Scattered interconnected cells or ganglia are sparsely spread along the cardinal veins from the heart to the level of the anus (Kuntz, 1911b; Kraus, 1923; Nicol, 1955; Goodrich 1958). Sympathetic ganglia in elasmobranchs are segmentally but loosely arranged along the vertebral column, and there is no sympathetic encroachment in the head region. In teleosts, an organized sympathetic cord with regular ganglia interconnected by longitudinal strands is characteristic, and sympathetic fibers pass into the cranial region (Young, 1931a; Young, 1933a; Hirt, 1934; Daniel, 1934). In amphibians, particularly in anurans, a well-organized basic pattern of the autonomic nervous system, with clearly defined sympathetic and parasympathetic divisions, is found. Work concerning the autonomic nervous system in reptiles and birds (Terni, 1931; Hirt, 1935; and others) indicates that this system is rather similar to that of mammals in its general basic organization. It is distinctly divided into craniosacral and thoracolumbar divisions, and limited information indicates that its function may approach, in diversity and complexity, that found in mammals.

Functionally, the sympathetic and parasympathetic systems seem to exert increasing numbers of discrete effects from elasmobranchs to mammals. In elasmobranchs the vagi have an inhibitory effect on cardiac activity, and sympathetic fibers exert a motor effect on abdominal viscera (Lutz & Wyman, 1932; Young, 1933a; Nicholls, 1934). In teleosts, the sympathetic system also exerts influence upon the eyes, chromatophores, swim-bladder gland and blood vessels, in addition to the functions present in elasmobranchs. The control of the sympathetic system over the heart and intestinal glands is gradually extended in amphibians (Müller & Liljestrand, 1918; Young, 1931). In mammals, the autonomic system has been considered to play important roles in maintenance and regulation not only of visceral activities, but also in reproduction, homeostasis, and in stress. Its widespread influence in the human being

is clearly shown in many excellent studies, such as those of Cannon (1936), Gellhorn (1943), Kuntz (1951) and others. It should be pointed out, however, that experimental studies of the autonomic nervous system in lower mammals and other vertebrates are extremely few, in comparison to the intensive work which has been done with higher mammals. It may well be that, despite its diffuse morphologic organization in lower forms, the autonomic nervous system subserves many more discrete functions than those presently recognized.

This survey of the morphology of the autonomic nervous system in the opossum indicates that its organization (fig. 12) is quite consistent with that which might be expected in a generalized mammal. The basic pattern is somewhat advanced over that in reptiles, and is fundamentally like that of other mammals. The sympathetic system appears as two longitudinal ganglionic chains which extend from the base of the skull to the sacral region; each chain connects with the segmental spinal nerves by communicating rami. Cranially, each trunk gives rise to fibers which follow blood vessels to supply structures in the head. Numerous filaments arise from the trunks to innervate the viscera directly or to enter prevertebral ganglia. The parasympathetic division is represented by fibers of the third, seventh, ninth and tenth cranial nerves and their related ganglia, and by the pelvic nerves derived from the first and second sacral spinal nerves. The similarity of this system in the opossum to that in both lower and higher vertebrates is, perhaps, an indication that this is a primitive and conservative system well adapted to make necessary internal adjustments to changes in both internal and external environment.

There are, in the opossum, numerous slight variations of the autonomic nervous system from conditions described in other mammals. Although the functional significance of these variations cannot be evaluated at this time, it is worthwhile to consider them in some detail.

Unlike the cat, rhesus monkey and human being in which the cervical spinal nerves are connected with the sympathetic trunks by communicating rami derived from the cranial cervical, middle cervical and lower cervical or stellate ganglia, the lower five cervical spinal nerves (fourth, fifth, sixth, seventh and eighth) in the opossum receive communicating rami that originate from the cranial pole of the stellate ganglion. These communicating rami arise from a common root which travels with the vertebral artery. Communi-

cating rami of similar origin and pattern are described in some mammals by Broek (1908) and Hirt (1935); these workers designate the common root of these rami the vertebral nerve, a term which seems appropriate to apply to the structure in the opossum. Microscopic study indicates that no intermediolateral cell column is present in the cervical region of the spinal cord, so it would seem that the communicating rami arising from the vertebral nerve are composed of postganglionic fibers arising from the upper thoracic levels of the cord. Although no communicating rami were found to join the upper three cervical spinal nerves, it is probable that they are present and that they arise from the cranial cervical sympathetic ganglion as in certain other mammals; Broek (1908) figures and describes this pattern in several forms, and communicating rami to all spinal nerves of the cervical region have been found to be present in representatives of all vertebrate groups from teleosts to mammals. Work by Terni (1931), Hirt (1935) and others indicates that, in reptiles and birds, the cervical sympathetic trunk consists of superficial and deep portions; in some cases in birds the former may fuse with the vagus nerve, and the latter, the vertebral nerve, always travels with the vertebral artery and is connected with the cervical spinal nerves by communicating rami. The origin and pattern of the vertebral nerve in the opossum and, according to Broek, in some other mammals (unfortunately unnamed), appears to be more comparable to that in reptiles and birds than to the single cervical sympathetic trunk in the cat, rhesus monkey and human begins. It would be attractive to interpret this as an indication of a relatively primitive condition of the autonomic nervous system in the cervical region, but data available are inadequate to warrant such a conclusion.

The sympathetic trunk and the vagus nerve are separate in the opossum, as they are in the rhesus monkey (Kuntz, 1933) and human being (Kuntz, 1953). Broek (1908) classifies mammals in which the sympathetic trunk is separate from the vagus nerve in the cervical region as members of one of two major groups; the second group includes those mammals in which the cervical sympathetic trunk is fused intimately with the vagus nerve, as is the case in the dog and cat. This classification seems to be questionable, since many variations of relationship exist between the extremes of total fusion and complete separation. For example, connections by fine branches between the cervical sympathetic trunk and the vagus nerve have been found at various levels in the rhesus

monkey and human beings; in some cases, partial fusion of the two trunks may be present in the lower part of the cervical region in the cat. In the opossum, however, there is no connection between the sympathetic trunk and the vagus nerve. This complete separation of the sympathetic trunk from the vagus nerve in the cervical region of the opossum may be another indication of less complexity or of a more primitive pattern of the autonomic nervous system than is found in other mammals.

In comparing the cardiac plexus of the opossum to that in the cat, dog, rhesus monkey and human being, it is notable that the cardiac nerves derived from the sympathetic trunk and vagus nerve are fewer in number in the opossum, and that the sympathetic cardiac nerves are derived chiefly from the stellate ganglion and the trunk immediately above the stellate ganglion. There are no sympathetic cardiac nerves derived from the cranial or middle cervical ganglia or from the cephalic portion of the cervical sympathetic trunk, as is the case in the cat, rhesus monkey and human being. In the latter forms mentioned, the cardiac plexus is formed by two or three sympathetic cardiac nerves derived from each thoracic sympathetic trunk, plus three or more cardiac fibers contributed by each cervical sympathetic trunk. In the opossum only one cardiac fiber is contributed by each of the cervical sympathetic trunks, and three sympathetic cardiac nerves are contributed by the stellate ganglia, one from the right and two from the left; no cardiac nerves arise from the sympathetic trunk below the level of the stellate ganglion. Unlike the condition in the human being, in which each vagus nerve gives off two cardiac nerves in both cervical and thoracic regions, each vagus nerve in the dog, rhesus monkey and opossum gives off only one cardiac nerve in the cervical region and, in the case of the cat, it gives off none; in the thoracic region, the vagus nerve usually gives rise to two, three, or sometimes more cardiac branches in all of these forms. The relative sparseness of the cardiac plexus and the limited number of small cardiac nerves contributing to it lead one to speculate concerning the amount of control the autonomic nervous system exerts over the heart in the opossum. It would be interesting to determine whether or not such control is comparable to that found in more active and vigorous forms.

The source of the esophageal plexus in the opossum is similar to that in the cat, dog, and human being in that it is derived from the sympathetic trunks and vagi of the cervical and thoracic regions,

but the number of fibers contributed to the plexus is smaller and the network is inconspicuous in the opossum in comparison to that in the other forms mentioned.

In the region of the subclavian artery in the cat and human being the thoracic sympathetic trunk continues into the cervical region dorsal to the subclavian artery, and slender loop, the ansa subclavia, passes ventral to the artery (Kuntz, 1953; Reighard and Jennings, 1961). In contrast to the condition in these mammals, the ansa subclavia in the opossum is large and appears to form the major connection between the thoracic and cervical parts of the sympathetic trunk. It gives rise to the sympathetic cardiac nerves and to fibers which accompany the subclavian artery of the same side. The size of the ansa subclavia may be the result of the manner or sequence in which the stellate ganglion is formed in relation to the subclavian artery, or to a more complex developmental pattern, since fibers contributed to the cardiac and esophageal plexuses arise primarily in this region.

The levels at which the thoracic splanchnic nerves originate from the sympathetic trunk vary considerably in mammals. In the human being the splanchnic nerves are derived from the fifth to the twelfth thoracic vertebral level (Kuntz, 1956). In the cat, they are described as originating from the twelfth thoracic to the first lumbar vertebral level (Kuntz, 1956). The splanchnic nerves arise from the thirteenth thoracic and the first lumbar vertebral levels in the dogs and rhesus monkey (Kuntz, 1933; Mizeres, 1955); these splanchnic nerves, in most cases, unite as one single trunk to enter the abdominal region. In the opossum, the splanchnic nerves are derived from the tenth or eleventh thoracic to the first lumbar vertebral level (except for one case in which the greater splanchnic receives a contribution from the ninth vertebral level) and are joined in a completely inconsistent manner by interconnection, combination or division between the splanchnic nerves. The relatively low origin of the splanchnic nerves is consistent with the condition found in animals which have not (unlike the human being) been involved in a complex pattern of evolution of the vertebral column. The lack of consistency in the manner in which the splanchnic nerves are formed might be considered to be indicative of a rather primitive (or unstabilized) developmental pattern in this part of the sympathetic nervous system; this constitutes, however, only a speculative possibility, since considerable variation in the pattern of formation of the splanchnic nerves does exist in other species.

Unlike the cat, dog, rhesus monkey and human being in which the caudal (inferior) mesenteric ganglion is intimately associated with the artery of the same name, the caudal mesenteric ganglion in the opossum is located, not on the caudal mesenteric artery, but in the mesentery approximately twenty millimeters above the bifurcation of the abdominal aorta. As in the other forms mentioned, the caudal mesenteric ganglion receives fibers mainly from the intermediate mesenteric plexus, the celiac ganglionic complex and the splanchnic fibers of the lumbar ganglia, and it serves as the main source of the sympathetic fibers to the descending colon, rectum and gonads. The position of the caudal mesenteric ganglion appears to be related to the position of the caudal mesenteric artery; it would seem that the ganglion has undergone partial migration from its usual position toward the unusually placed artery. This suggests that the pattern of placement of sympathetic ganglia and fibers in close association with blood vessels may well be of more significance than is commonly assumed.

In the sacral region, it is of interest that there is no ganglion impar recognizable in the opossum; it is probable that the communications between the two sympathetic trunks may have isolated ganglion cells in association with them, and structurally and functionally replace the true ganglion of other forms. The sacral autonomic nerves or pelvic nerves are derived only from the first and second sacral nerves in the opossum; the equivalent nerves arise from the second and third sacral spinal nerves in cat (Reighard & Jennings, 1961), from second, third and fourth sacral spinal nerves in the human being (Kuntz, 1953) and from the seventh lumbar, first and second sacral spinal nerves in the rhesus monkey (Kuntz, 1933). The variation in the levels of origin of the pelvic nerves in the forms mentioned are, however, probably related to variations in numbering of vertebrae rather than to changes within the central nervous system and its branches.

The number of sources contributing to the pelvic viscera (especially the gonads) in the opossum is similar to that in the human being; the gonads in both receive fibers from the renal plexus by way of the ureter, from the gonadal ganglion and intermediate mesenteric plexus via the gonadal artery, from the hypogastric plexus by way of the branch of the artery of the same name and from the pelvic plexus. The rich contribution of fibers from sources situated as far cranially as the renal plexus seems to be here, as in

other forms, an indication of a developmental process in which the elongation of the body and descent of the viscera extend the fibers to their final position.

Among the cranial autonomic ganglia in the opossum, only the submaxillary ganglion differs significantly from that in the human being in relative size and in location. It is less than one millimeter in diameter, the smallest of the four ganglia. Since the submaxillary gland is located farther from the oral cavity in the opossum than it is in the human being, the submaxillary duct is comparatively longer, and the submaxillary ganglion is located far back on the common duct immediately before it is formed by the union of the submaxillary duct and the duct of the sublingual gland. It seems reasonable to assume that the ganglion has been carried posteriorly in the course of caudal migration of the gland in the growth process, and that its small size and diffuse nature may be indicative of synaptic stations firmly associated with the gland itself.

Although fibers from the otic ganglion to the auriculotemporal nerve were not recognizable, a filament from the lateral aspect of the otic ganglion to the mandibular nerve was observed. This latter filament may be secretory in nature and may eventually follow the auriculotemporal nerve, a branch of the mandibular nerve, to reach the parotid gland.

SUMMARY

The general morphology of the autonomic nervous system of the opossum, as it is revealed by gross silver staining and dissection, is described in some detail. The thoracolumbar division arises from the last cervical vertebral level of the spinal cord cranially to the third or fourth lumbar vertebral level caudally, and is fundamentally similar in its morphology to that of other mammals. The cervical portions of the sympathetic trunks do not communicate with the vagi and communicate with the thoracic portions primarily by way of the ansa subclavia. The prevertebral ganglia of the abdominal region are poorly differentiated, one from another, and no definitive ganglion impar is recognizable.

The four cranial autonomic ganglia are similar to those in other mammals, except that the submaxillary ganglion is small and diffuse and is located immediately anterior to the common duct formed by the union of the submaxillary duct with the duct of the sublingual gland.

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KEY TO ABBREVIATIONS

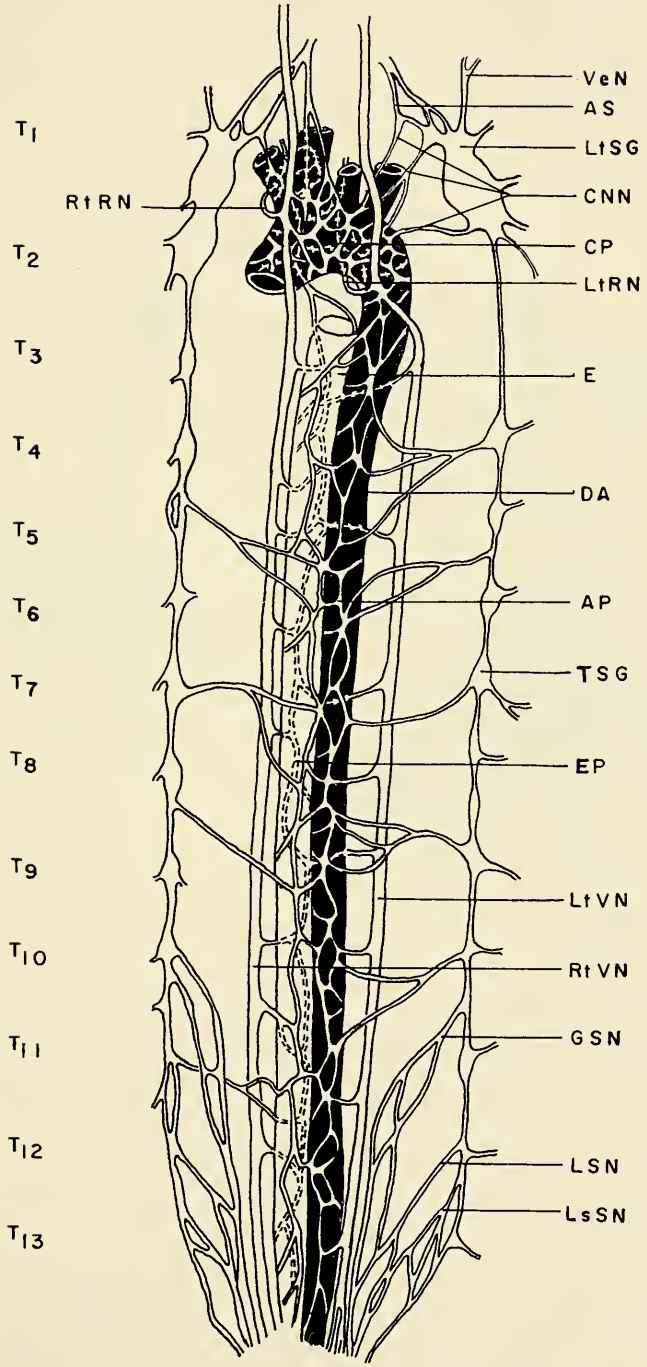
A—aorta
AG—adrenal gland
AP—aortic plexus
ARG—aorticorenal gang.
AS—ansa subclavia
ATN—auriculotemporal n.
AbN—Abducens n.
CCA—common carotid a.
CCSG—cranial cervical sym. gang.
CG—ciliary gang.
CLN—cranial laryngeal n.
CMG—cranial mesenteric gang.
CN—cardiac n.
CP—carotid plexus
CR—communicating ramus
CST—cervical sym. trunk
CTN—chorda tympani n.
CaCSG—caudal cervical sym. gang.
CaMG—caudal mesenteric gang.
CeG—celiac gang.
CoP—coronary plexus
DA—descending aorta
DCP—dorsal cardiac plexus
DD—ductus deferens
DPN—deep petrosal n.
E—esophagus
EN—ethmoidal n.
EP—esophageal plexus
EPM—ext. pterygoid m.
GA—gonadal a.
GAA—gastric a.
GG—gonadal plexus
GSN—greater splanchnic n.
HP—hypogastric plexus
HeP—hemmorrhoidal plexus
IAN—inf. alveolar n.
IMP—intermediate mesenteric plexus
IN—infraorbital n.
IOM—inf. oblique m.
IPM—int. pterygoid m.
LG—lacrimal gland
LI—large intestine
LN—lingual n.
LR—long root
LSG—lumbar sym. gang.
LSN—lesser splanchnic n.
LSPN—lesser superficial petrosal n.
LSpN—lumbar splanchnic n.
LsSN—least splanchnic n.
MCG—mid. cervical gang.
MN—maxillary n.
MPN—major palatine n.
NG—nodose gang.
OG—otic gang.
ON—oculomotor n.
ON-Id—oculomotor n., inf. div.
ON-Sd—oculomotor n., sup. div.
OP—ovarian plexus
OpN—optic n.
PA—phenic a.
PCN—n. of pterygoid canal
PG—parotid gland
PNN—post. nasal n.
PP—pulmonary plexus
PeG—pelvic gang.
PeN—pelvic n.

PeP—pelvic plexus
PrG—prostate gland
PuN—pudendal n.
R—rectum
RN—recurrent n.
RP—renal plexus
SA—subclavian a.
SCN—short ciliary n.
SG—stellate gang.
SLD—sublingual duct
SLG—sublingual gland
SMD—submaxillary duct
SMGl—submaxillary gland
SP—splenic plexus
SPG—sphenopalatine gang.
SPLM—sup. palpebral levator m.
SPN—superficial petrosal n.
SRM—superior rectus m.
T—trachea
Te—testis
TN—trochlear n.
TSG—thoracic sym. gang.
U—uterus
UB—urinary bladder
UP—ureteric plexus
UgA—urogenital a.
UgS—urogenital sinus
Ur—ureter
UrP—uteric plexus
V_1—ophthalmic n.
V_2—maxillary n.
V_3—mandibular n.
V_3-ab—mandibular n., ant. br.
VCP—ventral cardiac plexus
VN—vagus n.
VP—vaginal plexus
VeN—vertebral n.
VeP—vesical plexus

FIGURE 1

FIG. 1. The thoracic portions of the sympathetic trunks and vagus nerves, and the aortic and esophageal plexuses in *Didelphis marsupialis.* × 1

FIGURE 1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VeN
AS
LtSG
CNN
CP
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DA
AP
TSG
EP
LtVN
RtVN
GSN
LSN
LsSN

FIGURES 2-4

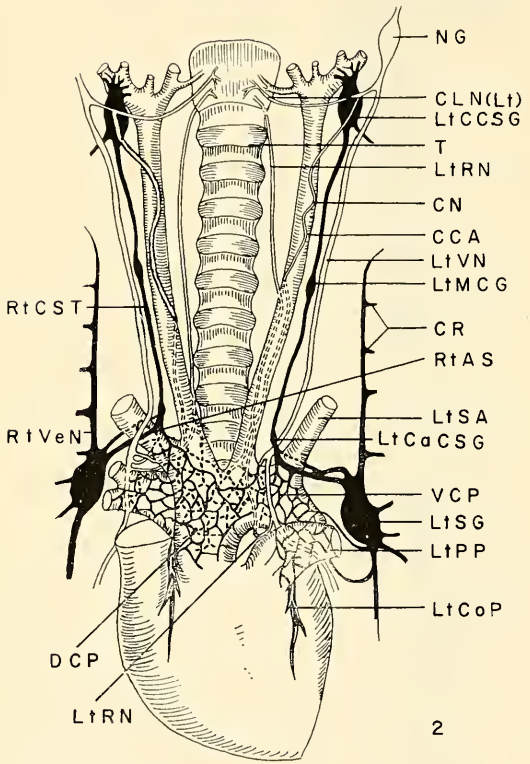

FIG. 2. The cervical sympathetic trunks and vagus nerves, ventral view. Note relationships to major structures of the neck and to cardiac plexus. × 1.25

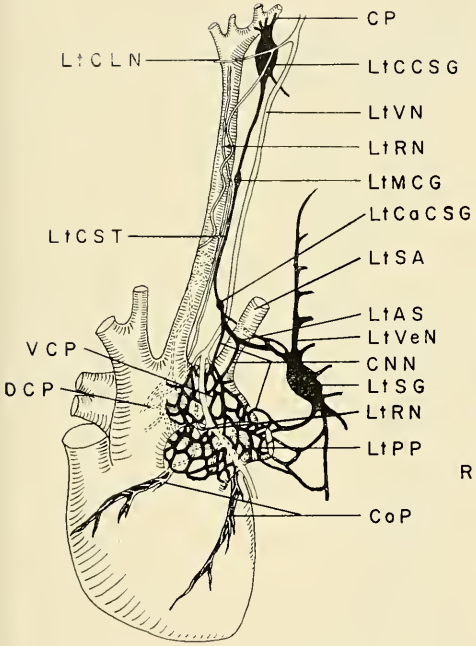

FIG. 3. Left cervical sympathetic trunk, left vagus nerve and their contribution to cardiac plexus; ventral view. × 1.25

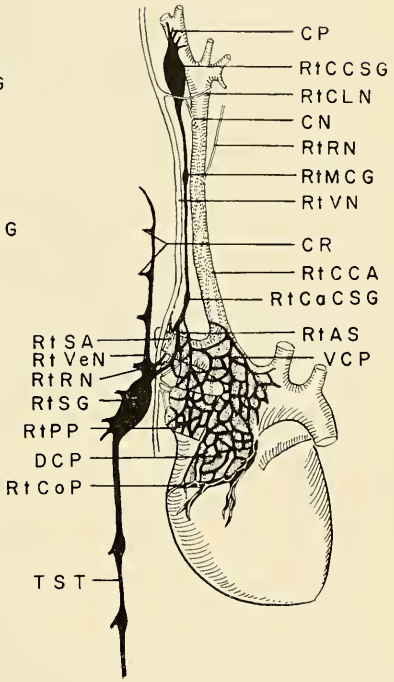

FIG. 4. Right cervical sympathetic trunk, right vagus nerve and their contributions to cardiac plexus; ventral view. × 1.25

FIGURE 5

FIG. 5. The lumbar sympathetic trunks and adjacent pre-aortic ganglia and plexuses; ventral view. × 1

FIGURE 5

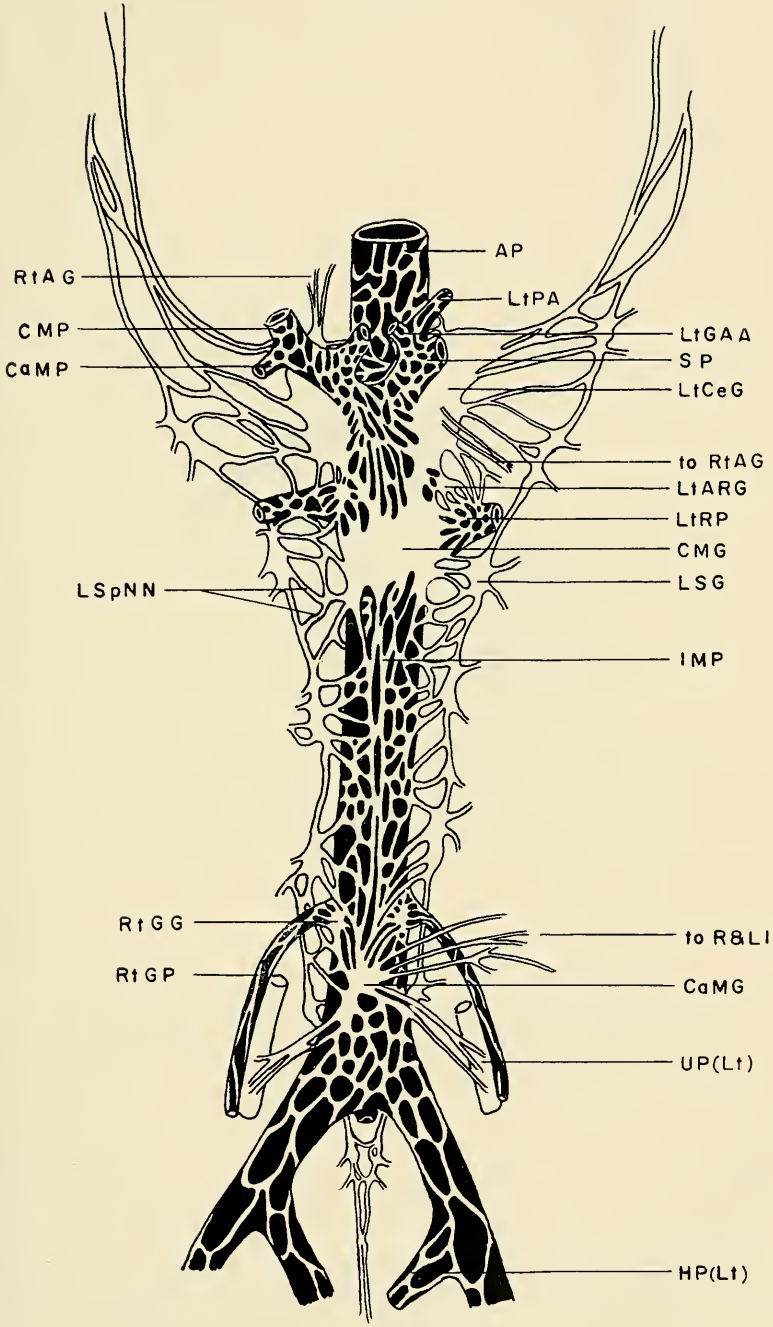
AP
RtAG
LtPA
CMP
LtGAA
CaMP
SP
LtCeG
to RtAG
LtARG
LtRP
CMG
LSpNN
LSG
IMP
RtGG
to R&LI
RtGP
CaMG
UP(Lt)
HP(Lt)

FIGURE 6

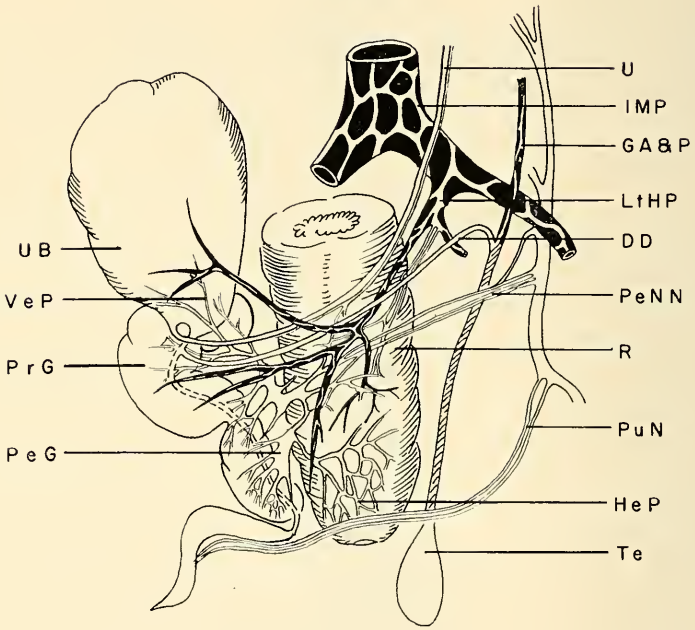

FIG. 6. Pelvic plexus in male specimen. Pelvic viscera have been turned toward the right, and the left half of the plexus is represented.

FIGURE 7

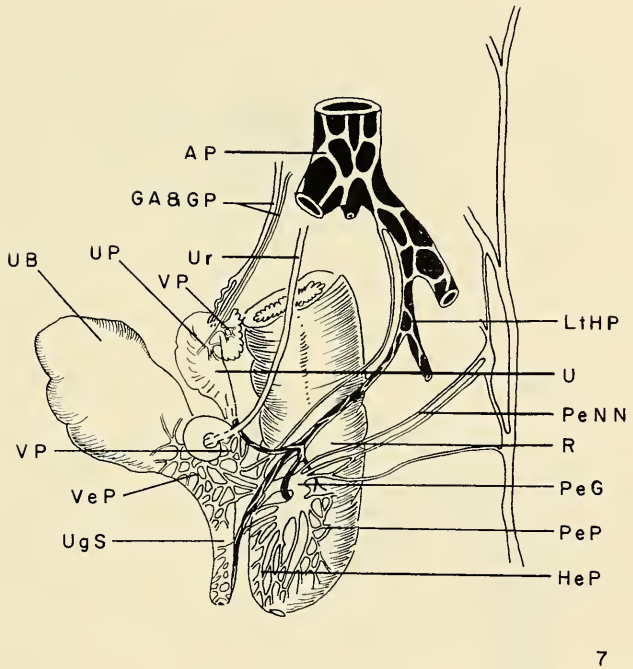

FIG. 7. Pelvic plexus in female specimen. View is as in fig. 6. × 1.

FIGURE 8-9

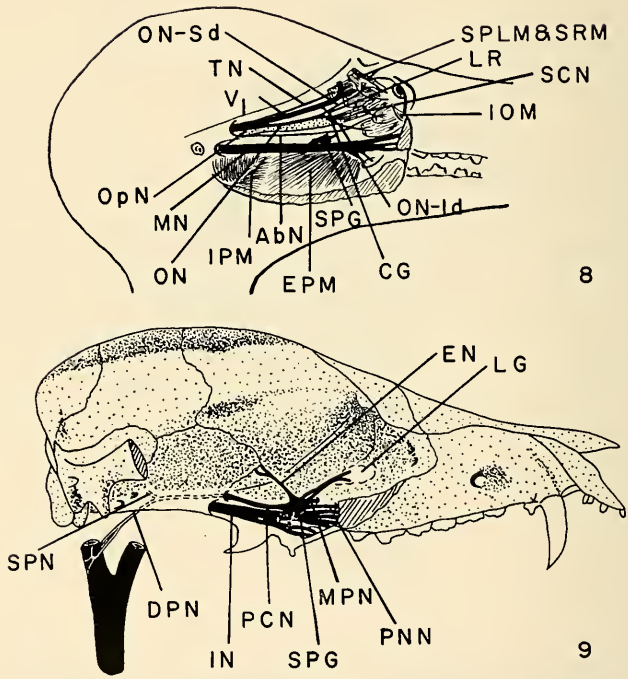

FIG 8. The ciliary ganglion and its relationships to major structures of the orbital region; semidiagrammatic. × 1.12

FIG. 9. The spenopalatine ganglion. × 1.12

FIGURE 10-11

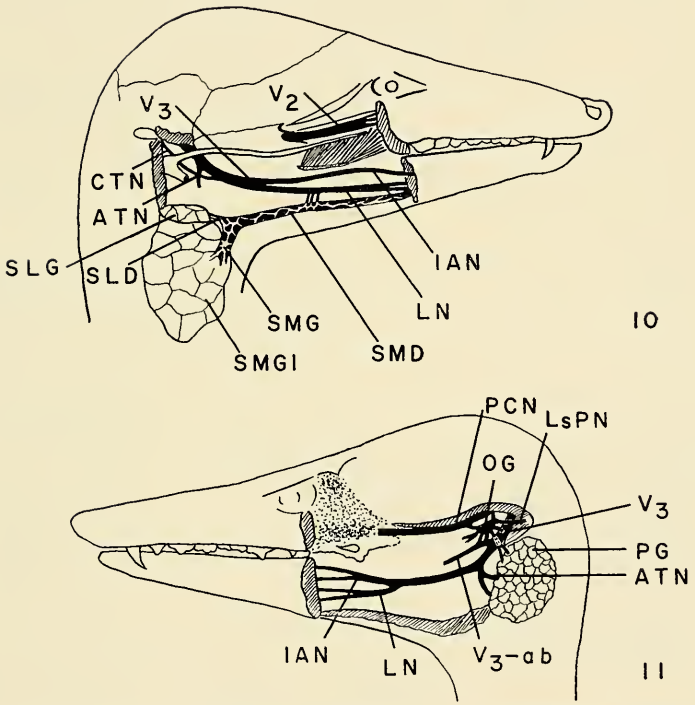

FIG. 10. The submaxillary ganglion and its significant relationships; diagrammatic. × 1.12

FIG. 11. The otic ganglion and its major connections; diagrammatic. × 1.12

FIGURE 12

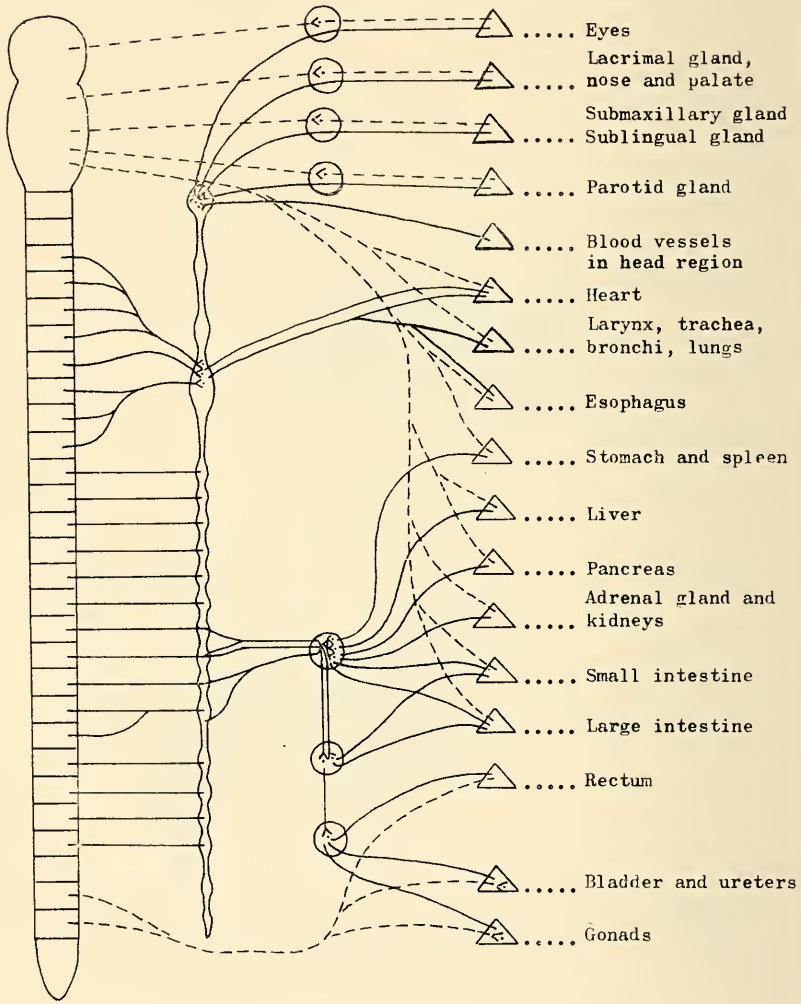

FIG. 12. Schematic summary of the distribution of the autonomic nervous system in *Didelphis marsupialis*. × 1

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The Structure and Innervation of the Venom Glands in the Tail of the Salamanders (*Ambystoma*)

BY

GRANT A. MASON, JR.
JAMES L. HALL
PAUL GIBBONS ROOFE

Department of Anatomy, University of Kansas, Lawrence, Kansas

ABSTRACT

1. Twenty-two adult salamanders were used in this experiment, three for histological examinations, five for autonomic drug experiments, and the remainder for stimulation of the sectioned spinal cord.

2. The histological examination revealed nerves running among the smooth muscles of the acinus walls.

3. The autonomic drug experiments indicated that the nerves were from the sympathetic nervous system.

4. Stimulation of the sectioned spinal cord disclosed that the different levels of the thoracic and lumbar portions of the spinal cord (segments 10-15), when individually excited for a short period of time, would cause a segmental secretion on the tail.

5. Prolonged excitation of segments 10-15 will eventually cause secretion to appear on the entire dorsal surface of the tail, indicating the presence of a nerve syncitium.

6. This entire study proved that the walls of the poison skin glands in the tail of the salamander are innervated by sympathetic nerve fibers that have their cells of origin in spinal cord segments 10-15.

INTRODUCTION

The existence of "poison" skin glands in the tail of the salamander has been known for a great many years. According to Francis (1934), Leydig (1876), Pfitzner (1880), and Brasch (1894) were among the earliest known investigators to do research in regard to the development and histology of the "poison" glands. Zalesky (1866), also cited by Francis, was the first worker in the field to elucidate the chemical nature of the substance secreted by the

venom glands, indicating that there probably had been some work done on these skin glands and their secretion prior to his investigations. The above mentioned authors, along with more recent studies, Noble (1931), point out that the skin glands are of two kinds, mucous and poisonous.

However, an extensive review of the literature does not reveal the mechanisms involved in the activation of the glands and the exact manner of their innervation. A limited number of papers have been published on the autonomic nervous system of the salamander. Francis attributes to Andersson (1892), and Jaquet (1900), the first investigations in this area, the latter one being based upon the former and thereby suffering from some incompleteness found in the first work. Hoffmann's (1902) paper on the development of the sympathetic nervous system (sympathetic here referring to the autonomic nervous system as a whole) added several important details in this field.

The literature, since the early 1900's is lacking in references to these venom glands and their innervation. This paper deals with the relationship between the glandular structure and the autonomic nervous system.

This study was undertaken in order to determine the true nature, morphology, and innervation of the "poison" glands in the tail of the salamander. For this project the authors had available a limited number of adult salamanders, *Ambystoma tigrinum melanostictum* (Tiger Salamander) collected from the Jackson Hole area in Wyoming, and a large quantity of adult *Ambystoma annulatum* obtained through a biological supply house. Histological examination of the skin glands, gross dissection of the spinal cord, and injection of autonomic drugs, coupled with electrical stimulation, were made. The results indicate that the venom glands in the tail of the salamander are under the control of the sympathetic nervous system.

SURVEY OF THE LITERATURE

There is a scarcity of literature related to the "poison" skin glands and their direct innervation. Therefore this survey was conducted in two phases: one, that covering the glands of the skin, and two, that covering the autonomic nervous system of the salamander and that system's relationship to the innervation of the skin glands.

The literature dealing with the skin glands specifically is quite extensive. After the beginning of the 1900's there is a definite lack of pertinent references. The most recent reference that the

authors found was that of Francis (1934). This monograph, in regards to the skin glands and the autonomic nervous system, presents brief summaries of the more pertinent details found in many of the earlier works. The earliest report of these "poison" glands is by Ascherson (1840). Esterly (1902) says that Ascherson was the first to make the distinction of the two types of skin glands in an investigation of the glands of the live frog. It was Engleman (1872), however, who first used the terms 'Schleimdrusen' and 'Kornerdrusen,' thus recognizing the existence of the two types of glands. The literal translations of 'Schleimdrusen' and 'Kornerdrusen' are slime-forming gland and granular gland. This would seem to indicate that Englemann was using the word 'Schleimdrusen' to refer to mucous glands and the word 'Kornerdrusen' to signify venom or "poisonous" glands (serous glands). Most investigators share the opinion that there are two morphologically different types of glands yet the criteria for the differentiation has not always been the same.

The early classification such as non-contractile versus contractile, clear versus granular, or mucous versus poison were based on the difference in structure, physiological activity, and secretion. Dawson (1920) says that Englemann's 1872 classification is accepted to a degree. However, there is a diversity of opinion regarding the granular and poisonous glands. Dawson points out that Bruno (1904) classified the glands in *Rana esculenta* as holocrine and merocrine glands. It is not clear just what Bruno meant by this classification. Bruno probably was referring to the poisonous glands as being the holocrine type and the mucous glands as being the merocrine type. Physiological studies before and after Bruno as well as experimentation by Phisalix (1900), Hubbard (1903), and Shipley and Wislocki (1915) have proven conclusively that the skin of many amphibians secretes a poisonous substance. According to Phisalix, cited by Dawson, the poisonous glands are found not only on the dorsal surface, as most investigators had stated, but are also located on the ventral surface of the salamander. Previously, the majority of investigators who described the location and distribution of the poison glands stated that they are found in the dorsal skin only. In this case, dorsal refers to an area from the mid-lateral line of one side of the tail, over the dorsal aspect of the tail of the salamander, to the mid-lateral line on the other side of the tail.

Several investigators have supported the concept of one type of skin gland. The skin of *Proteus*, according to Bugnion (1873),

as cited by Dawson, has only one type of gland corresponding to the mucous type of Dawson. Bugnion's results were supported by Muhse (1909) and Phisalix (1912). The Muhse paper established this idea on a firm basis. She believes that there exists in the cutis of the toad, only one kind of gland. She goes on to say that the more recent classification into mucous or poison, nuclear or granular, is based on a difference in the epithelial structure and in the secretion produced. This view had also been supported by Englemann (1872), Seeck (1891), and Bristol and Bartelmez (1908). Several investigators, Calmels (1883), and Junius (1896), according to Muhse, have given evidence or expressed their belief in one kind of cutaneous gland. He has excluded from his discussion, the glands of the ventral surface, which are mucous. He makes the statement that the poison glands which occur only on the dorsal surface differ from the mucous glands of the ventral side, in that they contain a milky secretion produced by the poison cells of these glands. He makes no mention of smooth muscle fibers about the glands. It is probable from his description that he has seen the muscle fibers but has mistaken them for endothelial cells, which they resemble very closely.

All of the authors who described one type of gland believed that the mature form was the granular—poisonous type while the mucous gland should be regarded as an immature or younger stage of the poisonous gland. Calmels (1883) and Juninus (1896), mentioned above, are ardent advocates of this idea. The criteria for such a differentiation is usually morphological but Esterly (1902), who speaks of poison and mucous glands, uses the difference in the secretion as a basis for classification. In his work on *Plethodon*, Esterly says that the largest poison glands are situated on the back of the tail, lying in that portion of the skin covering the dorsal half of the tail. Esterly points out that the two types of glands are further distinguished by other features, chief of which is the staining reactions for mucous secretion, as previously reported by Nicogla (1893), and Hoyer (1890).

A firmer basis for differentiation can be afforded by a physiological classification. Shipley and Wislocki believe "that this work (physiological) has given, . . . added evidence for the separation of the cutaneous glands . . . into mucous and poison varieties." They say "the criteria for differentiation of the glands are usually morphological" but, as in the case of Briston and Bartelmez (1908), and Esterly (1902), who speak of the poisonous

and mucous glands, the difference in secretion has been used as a basis for classification. Physiological activity, assuredly, affords a firmer, more secure basis for classifying anatomical structures than a morphologic peculiarity, which often results from the technique used in handling the material studied. Shipley and Wislocki believed that their analysis had given added evidence for the separation of the cutaneous glands of at least one, possible two species of toad into mucous and poison varieties.

While the literature on the poison skin glands of various *Batrachians* is fairly extensive, Bristol and Bartelmez are apparently the only authors who have more recently dealt with the toad. Bristol and Bartelmez said in a short note in *Science* which deals with the toad but a great deal of which holds true for the salamander:

> The poison glands are found only on the upper surface of the body while the mucous glands are found all over the skin . . . They are much larger than the mucous glands and extend deep down into the compact corium layers. They are surrounded by a thin layer of loose connective tissue, which contains nerve fibers and a dense network of capillaries. There is almost a continuous layer of smooth muscle fibers about the gland.

Hubbard (1903) says that a macroscopic and microscopic examination reveals the anatomical nature of the swellings surrounding the glandular openings on the skin. However, he fails to follow this statement up and does not tell us what the anatomical nature is. He states that the dorsal half of the epidermis of this organ is covered with minute and thickly crowded pores which can be seen with the naked eye. Muhse indicates that the epidermis of the toad has so-called warts in the dorsal skin caused by the grouping of the glands. According to Noble, the glands are often of large size and clustered in pads as in the parotid glands of the common toad or in ridges, as along the back of many species of Rana.

Reese (1905) did considerable work on the Giant Salamander. He was not able to determine whether or not there were two types of glands present in the epidermis. He did state that there were three distinguishable regions, an epidermal layer, a fibrous layer, and a muscular layer.

Perhaps the best way to sum up the controversy concerning whether one or two types of glands exist, would be to quote Dawson who said:

> "Two types of quite different glands are found. There is nothing to indicate that the smaller glands are young forms in the development of the granular 'poison' type. No genetic relationship between the two types has

been found. The glands are of two distinct types that differ in development, histological structure, in the staining reaction of their secretion, and in their physiological activities."

The preponderance of authors seem to agree on the definitive structure of the poison glands. Esterly has one of the best descriptions of glandular morphology. He contends that a layer of contractile or smooth muscle fibers is found between the connective tissue layer and the glandular epithelis. These fibers were first shown by Hensche (1856). The muscles of the large glands are arranged in a single layer and have a general moridional direction on the gland, converging toward the upper pole. The fibers are usually simple but may be branched, this occurring mostly on the lower part of the gland. The muscles do not form a continuous sheet about the gland; the individual fibers are separated by spaces of greater or lesser extent. Esterly also says that he was not able to find with certainty, muscles on the glands which were mucous in nature. The existence of a sphincter or constrictor muscle for the glands has been claimed by Schultz (1889), quoted by Esterly, who described a band of muscle fibers running around the neck of the gland. This observation, however, has been contested by Drasch (1889). Esterly also was unable to find such a structure in *Plethodon*. However, both dilator and constrictor muscles occur about the mouths of the poison glands of *Plethodon*. The fact that the constrictor and dilator fibers lie entirely within the epidermis need not contend against their having the function of muscles, for according to Esterly, it has been well established that the intrinsic gland musculature has an ectodermal origin.

Reese holds the opinion that the poison glands are not surrounded by a muscular layer; that there is a fairly distinct basement membrane surrounding the epithelium of the gland; and the muscular layer which is sometimes described cannot be clearly seen. He disagrees with Drasch who reported in the salamander a complete layer of smooth muscle around the periphery of large poison glands.

There is good evidence in fish, chiefly in *Fundulus*, according to Spaeth (1916) that the melanophere may be a disguised type of smooth muscle cell. Morphological and embryological evidence does not permit a clear differentiation between melanophores and smooth muscle cells. Spaeth's physiological data is by far the most conclusive support of the parallelism between smooth muscle and melanophores.

Muhse, as previously noted, goes into great detail and is quite explicit about the glands. Her description of the wall of the

acinus is clearly stated. It is her belief that in some cases the wall of the acinus is thin and the muscle fibers form a more or less continuous sheath. Muhse says that Drasch is the only investigator who has made any reference to a substance which encloses the muscles fibers and on which rests the epithelia. The muscle fibers are elongated and spindle shaped. Several fibers are required to complete the circuit of the gland. There is, therefore, no definite arrangement of the nuclei about any given part of the acinus. Seeck (1891) describes similar structures, i. e. the spindle cells, but considers them replacement cells for the epithelia. He denies that they are muscles cells.

The innervation of the smooth muscles related to the poison glands is not well understood. Noble makes the general statement that the autonomic nervous system consists of a cranio-sacral or parasympathetic outflow and a thoraco-lumbar or sympathetic outflow. The extent to which the complex sympathetic responses of defense are organized in the amphibian as compared to the mammal is not clear. There is little reason to doubt that the bodily defenses in the amphibian are mobilized in accordance with our basic concepts of the autonomic nervous system.

It was pointed out by Francis that there are only three investigations published on the complete autonomic nervous system of the salamander, Andersson's, Jaquet's, and Hoffmann's. Andersson's arrangement is the most convenient to describe the system in three divisions: (*a*) cephalic; (*b*) cervical and abdominal; (*c*) caudal. The caudal portion, in which the present paper is primarily interested, consists of a double chain lying along the caudal artery. The ganglia are approximately segmental in arrangement. Connections between the two sides are fairly frequent.

The histological detail of the innervation of the glands was described by Esterly. Among the workers who have been interested in this problem are Canini (1883), Frenkel (1886), and Massie (1894). The innervation of the glands received less attention. Eckhard (1849) first demonstrated that the glands could be emptied by stimulating the anterior roots of the cerebrospinal nerves, but did not consider the structure of the nerve endings. Eberth (1869) reported that there was a network of very fine fibers close upon the glands and Openschowski (1882) described a network of nerves surrounding the glands as well as an intercellular net. Drasch (1889) also experimentally proved by nerve stimulation secretion can be obtained from the glands, as did Phisalix-Picot (1900). Loeb (1896) has also shown how closely the innervation of the

glands of *Ambystoma* are connected with the central nervous system. In 1898 Herrick and Coghill were able to show the existence of an intimate connection of nerve fibers with the walls of the glands, but were unable to discover the exact relationship of the fibers to the gland cells. They also described the plexus of nerves beneath the corium as being composed of two types of fibers; larger ones connected with the nerve bundles of the central nervous system, and smaller ones originating in ganglion cells in the corium. Schuberg (1903) has conflicting views, contending that many or all the nerve bundles described are really connective tissue bundles, and that the ganglion cells are the "Mastzellen" which he himself describes.

Concerning the work of Herrick and Coghill, Massie supports the arrangement of the fibers beneath the corium and also shows that the nerves end on the muscles of the "ental" glands. "Ental" is a word taken from Herrick and Coghill's work and connotes the poison type of gland. These authors found that the nerve fibers passing from the nerve bundle plexus under the corium are intimately connected with the ental glands, and seem distinct from the nerves supplying the muscles. The endings upon the smooth muscles are shown both by Cajal's silver method and Mallory's fuchsin stain, and in some cases are typical as described by Huber and DeWitt (1897) and Coghill (1899). In many cases fine branching fibers can clearly by seen lying upon the muscle layer. Two types of nerve endings have been described. Huber and DeWitt report that the fibers ultimately become delicate, slender twigs which, without terminal expansions, always lie on a muscle fiber and end there. Herrick and Coghill have contested that the muscles are supplied by nerves with typical endings of expansions or bulbs, as well as by fine twigs without terminal expansions. Their investigations also revealed the possibility of a connection between the nerves enveloping the glands and the gland cells, but they were not able to demonstrate it. Both the musculature and the epithelia of the granular glands have a direct nerve supply. The gland cells are surrounded by a basket work of fibers, which in some cases have terminal expansions lying on the nuclei.

Spaeth was previously cited as stating that the melanophores were possibly disguised smooth muscle cells. Concerning the innervation of melanophores, Spaeth has this to report; "as we know, the activity of vertebrate smooth muscle is normally controlled through fibers of the sympathetic nervous system. Voluntary

motor connections do not ordinarily occur." The innervation of the melanophores has been satisfactorily demonstrated histologically by Ballowitz (1893) and physiologically by Pouchet (1876) in several species of Teleosts. Satisfactory histological demonstrations of the nerve endings in the melanophores of amphibians and reptiles have not been recorded. Simmerman (1878) and Hooker (1912) have demonstrated physiologically the sympathetic innervation in the melanophores of the frog and Carlton (1904) has made similar observations in *Anolis*. Thus, the question of melanophores possibly being disguised smooth muscle cells seems to be unsettled.

Herrick and Coghill state that they succeeded in securing excellent preparations in the toad in which they find it easy to trace non-medullated fibers from the ectad plexus of the corium into the most intimate connection with the superficial walls of the glands. These glands are very large and quite active in the toad. The fibers are of small caliber, excessively numerous, and envelop the whole gland in what at first looked, to the two investigators, like a closely woven reticulum, but a closer study showed that the appearance was due to the repeated dichotomous branching of a large number of distinct nerve fibers. These fibers cross at slightly different levels and there was little doubt, in most cases, of the complete distinctness of the fibers as they crossed.

The pyridine-silver nitrate-pyrogallic acid method of Ranson gave Dawson the best results in staining nerve fibers. This method did not affect the sheaths but left the axis cylinder black. With this procedure, Dawson was able to observe nerves forming a wide mesh plexus in the subcutaneous connective tissue. Small bundles passed out from these plexi to the smooth muscle of the glands. He found, however, no evidence of the presence of a stratum of ganglion cells as did Herrick and Coghill, or Coghill himself. Dawson also disagrees with Esterly who found fibers which ran for a long distance under the dermis and eventually turned upward toward the epidermis. It was Dawson's belief that only free intercellular fibers were found in the epidermis. The fact that these fibers seldom branched and were never found to terminate in small knobs or plates has been described for many Amphibia. The distribution of the nerves to the glands was not apparent to Dawson because of their extreme fineness. Nor did he observe perinuclear baskets of nerve fibers, such as Esterly has described for the poison glands of *Plethodon*.

As mentioned previously in referring to Herrick and Coghill's paper, the glands in the skin of the frog are of two classes, distinguished as the ental and ectal series. The ental series refers to the poison glands while the ectal series designates the mucous glands. The glands of both series are distributed regularly throughout the skin of the head. The peripheral cells of the ectal series are approximately cubical, becoming lengthened or depressed according to the shape of the gland and their position in it. The walls of these glands are made up of such cells, supported externally by the fibers of connective tissue. There appears to be no differentiated muscular elements connected with these cells. The glands of the ental series have a peripheral structure that is entirely different. As with the ectal series, there is a tendency for the connective tissue to fold about them, but within this tissue, lying compactly on the surface of the gland, is a complete tunic of nonstriated muscle cells. On close examination it was discovered that there were a number of tunic cells sufficiently impregnated to show conclusively that the fibers within their varicosities lie, not between the cells, but upon them. Herrick and Coghill were unable to trace these fibers to an entrance into a bundle or as a single fiber for any distance beneath the corium, as was done in the case of the terminal fibers. The function of the fibers arising from the lower stratum, seems to be more intimately related to the glands of the ental series, for these fibers pass peripherally in large numbers and embrace the entire surface of each gland. These fibers do not seem to be identical with those described as innervating the tunic cells of the ental series. It seems that there are two groups of nerves passing to the glands of the ental series; one attaching by typical endings to the enveloping muscle cells, and the other ramifying profusely over the surface of the gland.

The nerve fibers were first described in 1862 by Kolliker as cited by Huber and DeWitt (1897). It is now believed that the endings on the involuntary muscle tissue are the neuroaxes of sympathetic neurons, situated in, or at some more remote point from the smooth muscle in which such endings are found.

Two very contradictory views have been expressed on the ultimate ending of these nerves in the involuntary muscle tissue. On the other hand, it is asserted positively that the nerve fibers terminate on the muscle cells, while on the other hand, some investigators find that the nerve fibers terminate in the muscle cell, on or in the nucleus. The results of Huber and DeWitt confirm

the observations of those writers who contend that the free ending of the terminal fibers end *on* the smooth muscle cells.

According to Hubbard (1903), some doubt has been cast on the theories of protection afforded these glands in the animal kingdom that have been in favor for half a century. The glands of *Plethodon oregonensis* secrete a milky fluid when the animal is stimulated by an induction current, either on the back or on the tail. In a similar manner the glands respond to the touch of a drop of acid or to irritation in the form of stroking with a knife blade. The secretion turns blue litmus paper red and is therefore thought to be acidic. It does not appear to be a mucoid as it is insoluble in water. *Diemyctylus torèsus,* when stimulated electrically, also yields a copious milky secretion, not merely upon the tail, but generally over the whole dorsal surface. *Batrachoseps attenuatus,* on the other hand, yielded very little secretion when stimulated in any like manner (Cope, 1889). From a comparison of the structure and the action of the glands of *Plethodon* with those of other *Batrachia* in which the nature of the secretion is known, Hubbard attributes to the secretion a poisonous and protective function. He judges that the tail glands in *Plethodon* offer a partial protection to the animal. They may perhaps by some offensive odor or by some irritating, volatile product, ward off an enemy.

Noble (1931) postulates that the poison glands protect their owner from being devoured by many possible enemies. But these defensive properties do not always protect toads and salamanders from being eaten by snakes and other Amphibia. Three alkaloids have been extracted from the poison; Samandrin—$C_{26}H_{40}N_{20}$—being the principle one and affecting the respiratory area of the central nervous system of the predator.

Since the nature of the secretion and the function of the glands is not the primary objective of this paper, little more will be said about these two subjects. The purpose of the present investigation is to firmly establish the source of innervation of these venom glands and to determine the manner in which the nerve fibers terminated in relation to these glands.

MATERIALS AND METHODS

Nineteen live adult salamander, five *Ambystoma tigrinum melanostictum,* and fourteen *Ambystoma annulatum* were used with three previously formalin fixed adult species of *melanostictum* to conduct this study. All *melanostictum* were obtained by collection

in the Jackson Hole area of Wyoming. After collection, these animals were transported to Lawrence, Kansas, where these experimental procedures were performed. The *annulatum* used in this study were procured through a biological supply house. Bishop's *Handbook of Salamanders* (1943) lists the distribution of *annulatum* as "vicinity of Hot Springs, Arkansas, and Stone County, Missouri" and *melanostictum* as "British Columbia, Alberta, Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, South Dakota, and Nebraska."

All of the animals, prior to experimentation, appeared to be physiologically normal. The average weight of *melanostictum* was 56.1 grams and that of *annulatum* was 19.6 grams. The three previously fixed adults, mentioned above, were sacrificed in Moran, Wyoming at the Jackson Hole Biological Research Station and also transported to Lawrence, Kansas, for further investigation.

Each animal, preliminary to any investigation, was injected intermuscularly with a paralyzing drug, *Intocostrin* (E. R. Squibb and Sons, New York, New York). *Intocostrin* is an aqueous solution obtained from purified *Chondodrendron tomentosum* extract. The drug is believed to have an affect similar to that of a poison called curare (curari) used as an arrow poison by South American Indians. Its paralyzing action is reported to act upon the myoneural junction. This drug was used because it afforded normal physiological results without interfering with the action of the autonomic nervous system.

The first five animals, *Ambystoma tigrinum melanostictum,* were injected with 0.30 cubic centimeters of *Intocostrin;* approximately 0.15 cubic centimeters in both the dorsal pelvic and dorsal pectoral musculature. Fifteen minutes after this injection each animal was placed on its back. It was to establish whether or not the animal was anesthetized by pinching one of the animal's digits, to confirm the level of the withdrawal reflex. The skin covering the ventral aspect of the pectoral girdle was stripped away. Each of the two overlapping cartilaginous portions of the pectoral girdle was reflected laterally and held in that position with a hemostat. This operative procedure exposed the pericardium through which could be seen the beating heart. The thin pericardium was also removed, completely exposing the heart.

By means of a 1.0 cubic centimeter tuberculin syringe and a 30 gauge, ¾ inch hypodermic needle the different chemicals used in the experiment were injected into the heart.

Autonomic Drugs and Stimulation

Animal Number 1: Approximately 0.05 cubic centimeter of Adrenalin in 0.9% saline solution was injected into the ventricular cavity of the heart. A thirty second resting period followed the injection. Immediately ensuing this thirty second latent period a shock from an electronic stimulator, Model 751, 115 volts AC, 50-60 was administered via insulated electrodes to the dorsal portion of the tail at the spinal cord levels of S-1 through S-3. The stimulus has a frequency—pulse per second of twenty, a duration of ten milliseconds, and a voltage of three. At all times during the stimulation the tail was closely observed with the naked eye for any evidence of secretion. After obtaining the results of this experiment and allowing a sufficient amount of time for the glands to recover, the following four chemicals were also injected individually, in the same manner and quantity, into the heart. The chemicals were Prostigmine and Acetylcholine, Atropine, and Hexamethonium bromide. These were introduced individually and followed by stimulation. The chemicals, including Adrenalin, were used in a dilution of one part to one thousand parts of distilled water. The dosage was 1.0 milliliter per kilogram of body weight. A stimulation of the same intensity and frequency was applied in a similar manner and location in the case of each drug. A resting period of fifteen minutes was permitted after each phase (different chemical) of the experiment. This animal was sacrificed to be used in a staining technique for peripheral nerves by Williams (1943) whose report stated that he had obtained excellent results with amphibians. The procedure involved the macerating of tissue in KCN and immersing in Ehrlich's Hematoxylin.

Animals Numbers 2-5: The procedures of anesthetization, exposure of the heart, injection of the chemicals, stimulation, and observation used on animals number 2 through number 5 were identical to those used on animal number 1. The mode of procedure varied, however, in the number of chemicals used. Animals number 2 through number 5 had individual injections of Atropine, Adrenalin, Hexamethonium bromide, Prostigmine and Acetylcholine as well as another chemical, Ergotoxine ethane sulfonate. After the injection of Ergotoxine ethane sulfonate and normal stimulation, the voltage was increased to seven and the frequency raised to seventy-five and the animal was once again stimulated.

STIMULATION OF SECTIONED SPINAL CORD

Animals Numbers 6-12: This group of seven *Ambystoma annulatum* could not be considered to be a definitive experiment in themselves. They did, however, lay the background for the seven following animals and the experimentation performed on them. Each of the animals in this group was used to perfect a technique or techniques that were to be used later. The dorsal musculature covering the vertebral column was removed and the vertebra were opened to expose the spinal cord. The objective was to ascertain what sections of the spinal cord would elicit a secretion when stimulated. The cord was sectioned at various levels. The tail skin was observed when a stimulus was applied above and below the level of sectioning.

Animals Numbers 13-19: A similar procedure, as will be mentioned below, was used in this step of the investigation for each of the seven *Ambystoma annulatum.* All animals in this group received an injection of Intocostrin in the dorsal pelvic and dorsal pectoral musculature according to their weights, *i. e.,* 0.3 cubic centimeters per fifty grams of body weight. Under curare, the skin on the dorsal side of the thorax, half an inch on either side of the spinal column, from thoracic vertebra 1 to thoracic vertebra 15 was removed. It has been reported that the number of thoracic vertebra are not constant and can vary from thirteen to fifteen. Our study indicates only fifteen. The underlying thin spinal musculature was also removed. This step exposed the bony spinal vertebra. The spines and the dorsal half of the body of each vertebra were carefully dissected away, leaving the bare spinal cord lying in a trough created by the ventral portion of the thoracic vertebra.

The final step in this phase of the investigation was to individually sever each segment and stimulate it above the point of transection, observing grossly the reactions of the glands in the tail. Between severing and stimulation there was an interval of time to allow for recovery from the shock of the operation. The average time of the recovery period was fifteen minutes. The voltage of the stimulus was three, the frequency was twenty, and the duration was ten milliseconds. Each cord segment received a shock that had a length of two seconds. A twenty minute resting state followed each of the segmental stimulations.

Then, each segment that caused an initial secretion on the tail was again stimulated. The current was maintained on these segments until there was secretion over the entire tail or until it was evident that no matter the length or strength of the stimulus, no

secretion would be brought forth. This procedure gave a great deal more insight into the nerve distribution in the tail of the salamander. This procedure was adopted as a step in the investigation for the reason that a short period of stimulation on some of the caudal segments (12, 13, 14, and 15) of the thoracic cord would not cause secretion over the entire dorsal surface of the tail.

SECTIONING AND STAINING THE TAIL

Animals Numbers 20-22: The tails of these three animals, *Ambystoma tigrinum melanostictum*, were used to prepare the histological specimens required by this investigation.

Number 20: Immediately after death, this animal was placed in a 10% formalin solution where it remained until studied. When the animal was removed from the formalin its tail was severed from the body and prepared for dehydration. Among the necessary steps in the preparation was the removal of the vertebral column. The column was removed by placing an incision on the "nape" or extreme dorsal portion of the tail and one at the most ventral portion of the tail. These two incisions were continued toward each other, both splitting and going around the bony structure and meeting their fellow from the opposite side. Thus we had two pieces of tissue, a left and a right side of the tail. The amphibian skin was then dehydrated, embedded in paraffin, and serially sectioned at fifteen micra. Every tenth section was mounted and stained with Hematoxylin and Rosin.

Number 21: The same procedure as above was used except that the vertebral column was removed in such a way that the tail became a hollow cylinder permitting free access of the fluids to all its parts. The skin was stained with a modified Margolis-Pickett (1956) Luxol Fast Blue—Oil Red O method.

Number 22: The tail was cut into small sections, 10 mm. in length, after the entire animal had been fixed in 10% formalin. These tail sections were decalcified in a solution consisting of 10% nitric acid in 70% ethyl alcohol. The usual dehydration methods were used. Serial sections in paraffin were then impregnated with a modified Holmes silver technique.

RESULTS

AUTONOMIC DRUGS AND STIMULATION

Animal Number 1: Following the injection of 0.05 cubic centimeters of Adrenalin in 0.9% saline, there was an immediate doubling

of the cardiac rate to ten beats per five seconds. The electrodes were applied to the dorsal nape of the tail. When the current was turned on, the poison glands released a copius, white, sticky secretion within two seconds. The same shock was applied to the ventral regions of the tail but there was no evidence of any secretion.

Prostigmine, followed shortly (thirty seconds) by Acetylcholine was injected into the heart in quantities of 0.05 cubic centimeters. The second injection caused a primary cardiac acceleration which was soon altered to an over-all deceleration of three beats every five seconds. Similar to the Adrenalin injection, there was a slight watery appearance on the ventral side of the tail.

The third injection was Atropine. The procedures relating to quantity of the drug, injection, the waiting period, the stimulation, and observation were identical to those used in the Adrenalin and Prostigmine-Acetylcholine experiments. The results with this drug were very similar to those obtained when using the three perviously mentioned compounds. There was an immediate and copious secretion on the dorsal surface of the tail when it was stimulated. In this case there was no evidence of a watery secretion on the ventral surface.

Hexamethonium bromide was the fourth and final chemical used on animal number 1. There was none to very slight secretion on any portion of the tail when it was electrically stimulated. The only part of the tail that showed any evidence of secretion was the tip.

Animals Numbers 2-5: The four autonomic drugs used on animal number 1 were also used on animals numbers 2-5. The methods of experimentation were the same and the results were also identical. See Table 1. However, a fifth drug was introduced into these four animals.

The fifth chemical was Ergotoxine ethane sulfonate. It was injected in a quantity similar to that previously used on all the animals. The heart had almost an immediate slowing reaction. The rate was two beats per five seconds but each contraction was violent. In five minutes there was a distinctive blanching of the heart and the beats had slowed to one per five seconds. There was no evidence of any secretion elicited by stimulation other than on the last eighth of an inch of the tail. Even though the voltage and frequency as well as the length of stimulation were all significantly increased, no secretion was seen to come from the poison glands.

Stimulation of Sectioned Spinal Cord

Animals Numbers 13-19: Of the seven animals used in this step of the experiment, no secretion was ever observed when thoracic cord segments one through nine inclusive were stimulated. There was, however, a gradient found in segments ten through fifteen relating to the amount of secretion that came forth when the respective segments were stimulated. See Table II. Segment ten, when stimulated, caused the entire dorsal half of the tail to secrete. Segment eleven, like segment ten, also caused the entire dorsal portion of the tail to secrete. Segments twelve through fifteen however, caused a segmental secretion on the tail when stimulated. To clarify the above, we should note that segment twelve caused the caudal two-thirds of the tail to secrete, segment thirteen caused the caudal one-half of the tail to secrete, segment fourteen gave rise to secretion on the last one-third of the tail, and segment fifteen gave rise to secretion on only the very minutest portion of the tip of the tail.

The secretion, caused by stimulation of thoracic cord segments ten through fifteen, had only a slight delay from the moment the electrodes contacted the cord until the milky white fluid was seen. It was observed that stimulation of segments ten and eleven caused a secretion to appear over the entire tail. The secretory product, however, did not appear simultaneously over the entire dorsal surface. Here too, there was a step-wise gradient, the cephalic portion of the tail secreting first and a wave of secretion appearing to spread down the tail. The entire sequence, from the moment of stimulation until the dorsal half of the tail was covered with the secretion, took less than two seconds.

The most interesting results were found when the stimulation was continued over a period of time exceeding two seconds. Stimulation of segments ten and eleven was not necessary in this step for it had been found by previous experimentation that both of these levels gave secretion over the entire tail in less than two seconds. It was found that a continual stimulation of thoracic segments twelve through fifteen would eventually cause all of the poison glands on the dorsal portion of the tail to secrete. As one stimulated progressively down the cord, the longer the time lapse before the entire tail was covered with the poisonous secretion. Table II shows the length of time necessary for stimulation of the various cord segments before the secretion would appear. Seven

salamanders were used to compute the average time. *Ambystoma annulatum* was used to calculate the segmental times. Using ten specimens of A. tigrinum melanosticum with average weights (25 grams) a similar pattern of secretion was obtained in preliminary testing at the Jackson Hole Biological Station in the summer of 1960 (Roofe and Mason).

The Sectioned and Stained Tail

Animals Numbers 20-22: A histological examination of the poison gland cells was made utilizing two different types of staining techniques. The Luxol Fast Blue—Oil Red O method did not give clear cut results. Therefore, this study was limited to those slides stained with hematoxylin and eosin and Holmes silver stain. There is a single layer of smooth muscle fibers forming a continuous sheath or thin wall around the body of the gland. This sheath was barely thicker than two muscle fibers and this condition was infrequently noted and found only when one fiber overlapped another. A majority of the walls of the poison glands were one cell thick. Thin nerve fiber endings were found lying in intimate contact with these smooth muscle fibers. This observation confirmed the very early work of Hensche.

The normal poison gland cells appeared to contain three different types of secretion. There appears to be a gradient in the secretion's relationship to the surface opening of the gland. There is a mass of large, ovoid, cellular bodies close to the surface opening, occupying less than one-fourth of the total area of the gland. In the central two-thirds to three-fourths of the gland is another glandular mass composed of smaller spherical cells. The remainder of the secretion found within the unstimulated cell had the appearance of "protein" material, having no cellular outline and resembling a homogeneous mass.

All of the poison glands of the salamander, regardless of their volume, retained their ovoid or spherical shape.

A thorough survey of all the slides made failed to reveal any type of glandular epithelia. Several of the more prominent authors of the late 1800's, including Esterly, spoke of this epithelium.

DISCUSSION

Autonomic Drugs and Stimulation

The drugs employed in this experiment were chosen because of their single direct effect. Adrenalin potentiates adenergic nerve

endings and it was felt, that by use of this drug, if the glands were under sympathetic control, they would release an even greater quantity of secretion than the normal amount. However, there was no device to quantitatively measure the amount of secretion under the normal or experimental conditions and the glands seemed to give less secretion every time they were stimulated. Therefore, the resting period was introduced. This resting period apparently enabled the poison glands to replenish their secretion. It had been found that continual stimulation would exhaust the glands so that they would have little or no secretion remaining in them after several prolonged shocks.

Prostigmine and Acetylcholine, on the other hand, mimicked the action of the parasympathetic nervous system by potentiating cholinergic nerve endings. Prostigmine destroyed Cholinesterase which itself destroys Acetylcholine. Thus, when the Acetylcholine was introduced after the Cholinesterase had been destroyed, we had an increased action of the parasympathetic nervous system without disrupting the action of the sympathetic system. Once again the animal was stimulated and we had a copious secretion. This experiment in itself was not conclusive enough to prove whether the glands were under control of the sympathetic or parasympathetic nervous system. The watery secretion on the ventral surface of the tail, mentioned in the results, was from the numerous mucous glands covering the body. A discharge of mucous can be obtained by handling or a slight mechanical stimulation.

The third drug used was Atropine. This chemical blocked the cholinergic nerve endings. Therefore, in the way of negative proof, the copious secretion we obtained upon stimulation would tend to prove that the poison glands are under the control of the sympathetic nervous system. In other words, if there was a copious secretion when the parasympathetic nerve endings were blocked, the conclusion that the glands were under adenergic (sympathetic) control would be supported.

To be sure that the glands were under a nervous control simulated by the autonomic nervous system, Hexamethonium bromide was injected. This drug blocks synaptic transmission at the ganglion thus producing a total block of all autonomic nerve endings. Thus, when a stimulus was applied, there should be no evidence of any secretion. This drug was injected in order to determine whether the adrenal glands were causing the skin glands to be activated. If the adrenals were affecting the activity of the poison glands

we would expect a secretion in spite of the drug injection. When the stimulus was applied there was no evidence of any secretion, indicating two things. One, the glands were autonomically controlled and two, the adrenals had nothing to do with the secretion.

However, as previously stated, we had only negative evidence that the poison glands were controlled by the sympathetic nervous system. It was thought, therefore, that his previous set of experiments should be carried one step further. A drug that blocked the adenergic nerve endings was needed. Ergotoxine ethane sulfonate was chosen. Because of inconclusive data obtained from animal number 1, it was thought that this animal should not be included in Table I.

With all five different drugs at hand, four separate tests were performed. The results of these tests have been tabulated in Table I. One can see that every test, when repeated, gave results identical to those of the previous experiment. Likewise, the four experiments that were performed upon animal number 1, when repeated on animals number 2 through number 5, gave results similar to those found in the first animal. The fifth drug in Table I is Ergotoxine ethane sulfonate. The results with this drug support the contention that the poison glands are under sympathetic nervous control. Since there was no secretion on stimulation, the most obvious conclusion is that these glands are under autonomic nervous control and specifically, more the sympathetic nervous system. Ergotoxine had to be injected last because its affect was permanent in the dosage in which it was administered. In addition to this reason, the drug does not easily oxidize and would therefore remain in the system a long time, regardless of the dosage. The blanching of the heart, after the injection of Ergotoxine, was due to the imbalanced activity of the parasympathetic nervous system. The adenergic nerve endings, primarily the sympathetics on the coronary vessels, were blocked, causing an antagonistic constriction of these vessels and therefore blanching.

There might be objection to the previous statement that upon stimulation after an injection of Ergotoxine, "there was no evidence of any secretion other than the last quarter inch of the tail." This statement can be better understood if we realise that the circulation in the caudal quarter inch of the tail is quite poor. This could explain the slight secretion found when Ergotoxine had been introduced and the tail stimulated. Since the drug must reach the nerve endings by diffusion through the blood vessels and capillaries

and their distribution in the area is poor, it stands to reason that some of the nerve endings would not receive any Ergotoxine and therefore remain quite effective.

Williams (1943) method of staining peripheral nerves in cleared vertebrate tissue was attempted on animals one and two. The results of this procedure were not fruitful enough to permit the continuation of this method. The principal difficulty was the extreme fineness of the nerves thereby making it impossible to follow their course shortly after they left the spinal cord.

STIMULATION OF THE SECTIONED SPINAL CORD

Since it was determined that the glands of the tail were under sympathetic control, an attempt was made to determine the level of the spinal cord from which the fibers innervating these glands originated. Before this part of the experiment was begun nothing in the way of segmentation of the secretion was observed when the tail was grossly stimulated.

As there was some quantity of secretion whenever thoracic segments ten through fifteen were stimulated, we can say that the sympathetic nerves running to the walls of the poison glands have their cells of origin in these six thoracic cord segments. We can also state, as Table II indicates, that there is a segmental arrangement of these fibers with considerable overlap. This segmental arrangement and overlap have been pointed out in the results.

Stimulation of the more caudal thoracic cord segments (12, 13, 14, and 15) for a period longer than two seconds caused the entire tail to be covered with secretion. This lead to some speculation. At first it was believed that the stimulatory messages were being conveyed to the brain, primarily the hypothalamus, and then relayed back down to the poison glands. This, of course, would cause the slight delay noted when the electrodes are placed on the cord until the secretion appeared. Yet, this would appear to be difficult because most every known pathway that traversed back to the brain had been severed. The only logical conclusion that one is able to arrive at is that we have a local reflex arc and that there is a nerve syncitium that spreads throughout the entire tail. This syncitial arrangement would account for the slight delay before the tail is covered with the secretory product, as well as solve the problem that had arisen when all the pathways back to the hypothalamus and other autonomic regulatory areas had been severed. This syncitial net would also solve the problem of the wave of

secretion spreading up the tail when segments 12, 13, 14, and 15 were continually stimulated, rather than spreading down the tail as it would if the nervous messages were coming from the brain.

THE SECTIONED AND STAINED TAIL

Francis, when speaking of the autonomic nervous system, says that there are no special features to note other than the fairly frequent anastomoses between the two sides. He devotes considerable space in his monograph to the venom glands and does not mention the manner in which the glands are innervated. He completely ignores the thesis of glandular innervation.

When investigating the histological composition of the poison glands, the concepts of Spaeth were borne in mind. He thought that there was a good possibility that the melanophores could be disguised smooth muscle cells. We could find no good histological evidence that they (the melanophores) were directly innervated by the sympathetic nervous system. The melanophores, themselves, were easily identified as were the darkly staining fibers that ran through and among the muscular walls of the glands. Yet it could not be demonstrated satisfactorily to us that the nerve fibers actually terminated on the melanophores. The fibers passed close to the pigment granules but in no cases were knobs, boutons, or spindly endings seen to terminate upon these pigment granules.

Huber and DeWitt brought up the controversy of the true endings of the nerve fibers. They expressed the idea that two very contradictory views had been put forth; that nerve fibers may terminate in relation to the spindle shaped muscle cells or on or in the nucleus of the smooth muscle cell. We agree with Huber and DeWitt; the nerve terminals are *on* the muscle cells and in no case was it found that the free endings were on or in the nucleus of the muscle cell. This evidence corresponds to the work of Herrick and Coghill in 1898 who were able to show the existence of an intimate connection of the nerve fibers with the walls of the glands.

Dawson and several other investigators felt that there was definite epithelial layers associated with the wall of the gland. However, very close observation did not reveal any structure that resembled an epithelial layer. The difference in this particular part of the glandular morphology is very likely due to the fact that Dawson's investigations were on *Plethodon* while the present work is based on *Ambystoma tigrinum melanostictum.*

We modified the histological techniques to better suit the tissue at hand. A thorough examination of the first preparations revealed that too much detail had either been lost or was not able to be observed. Both the staining technique, Hematoxylin and Eosin, and the method of removal of the vertebral column were modified as described in the materials and methods.

The two modifications of the silver staining method mentioned in the materials and methods dealing with animal number 15 are as follows. The modification involved a shortening of several of the important steps (cutting the time in the impregnating solution from twenty-four hours to twenty-two hours and reducing the time in the reducing solution from two to five hours to one and one-half hours). This shortening seemed to stain the sections more in the manner desired, *i. e.*, more contrast. The original time sequence made the slides too dark and very little structure in the way of nerve fibers was discernible.

Our observations concerning the volume of the glands and thereby their shape (ovoid or spherical) followed the reports of Dawson, but were contrary to the ideas and writings of Drasch, Nierenstein (1908), Muhse, and Shipley and Wislocki.

The Reason for and Manner of the Secretion

The skin of the salamander is moist and devoid of scales. It is highly glandular and contains two different types of glands, the mucous glands, whose function it is believed, is to keep the skin moist, and poison or venom glands whose function will be speculated upon briefly. The manner of expulsion of the poison and its true chemical nature is somewhat of a mystery. When a salamander is irritated by chloroform, the white, milky fluid is seen to exude from the venom glands. Likewise, Dawson has said that the "granular secretion is expelled only in responses to some violent stimuli either mechanical, chemical, or electrical." He also believed that the secretion of the poison was due to the contraction of the smooth muscles found about the gland sacs. Seeck says that the expulsion is caused by underlying skeletal muscle. This idea of Seeck's can not be held as true because the primary injection of *Intecostrin* blocked all of the skeletal myo-neural junctions, rendering the skeletal muscle incapable of any response. Actually, later authors quite generally agreed that the expulsion of the secretion was due to smooth muscle contractions. Yet Calmels, like Seeck, did not attribute expulsion to the smooth muscle fibers about the

individual glands. Calmels did not describe or diagram, as such, a layer of smooth muscle fibers in the acinus wall. His statements regarding muscles are not clear, and Muhse felt that it was best not to attempt to state his position.

The secretion of the mature glands comes to the surface of the skin in drops. It is white or creamy in color, has a bitter taste, and a rather strong, disagreeable odor, very similar to that of Jimsom weed (rank-smelling foliage). Inside the mature glandular cell, the secretion as mentioned before, is primarily granular in appearance and takes stain readily, so that it always has a decided color, thus easily distinguished from the mucous secretions which are only very slightly affected by stains.

Noble reported that these granular glands produce a secretion which is usually more toxic than that of the mucous glands. It is believed that the secretion contains more than one poisonous constituent. Faust (1898), according to Noble, isolated Bufotalin, giving it the empirical formula of $C_{34}H_{46}O_{10}$. Francis states that Zalesky isolated the chlorohydrate of one of the alkaloids of the poison, which he called Samandrin. Abel and Macht (1911), in analyzing the secretion of the tropical toad, *Bufo agus*, said that the glands are under the control of the central nervous system.

Bristol and Bartelmez verified that the secretion had the reputation of being poisonous. They reported that it acted only on the mucous membrane, producing a result similar to that of curare.

CONCLUSIONS

In order to better understand the poison skin glands of the salamander under normal and stimulatory conditions, histological examinations, stimulatory experiments coupled with sectioning of the spinal cord, and autonomic drug injections followed by stimulation, were made on the tails of twenty-two adult salamanders.

We found that the walls of each of the poison skin glands was surrounded by a thin layer (one cell thick) of smooth muscle. In contrast to these walls, the mucous glands contained no smooth muscle in their walls.

In close and intimate contact with the smooth muscle cells of the walls are tiny, slender nerve endings. These fibers are from the sympathetic nervous system and come from thoracic cord segments ten through and including fifteen.

By the use of autonomic drugs and stimulation we found that the poison glands in the dorsal portion of the tail are innervated

TABLE I.—Secretion Results

CHEMICAL	Animal I	Animal II	Animal III	Animal IV
Atropine	Copius	Copius	Copius	Copius
Adrenalin	Copius	Copius	Copius	Copius
Hexamethonium bromide	Nothing	Nothing	Nothing	Nothing
Prostigmine and Acetylcholine	Copius	Copius	Copius	Copius
Ergotoxine ethane Sulfonate	Nothing	Nothing	Nothing	Nothing

TABLE II.

Thoracic cord segments	Results of two second stimulation of severed cord segments	Length of stimulation necessary to cause entire tail to secrete
1	Nothing	—
2	Nothing	—
3	Nothing	—
4	Nothing	—
5	Nothing	—
6	Nothing	—
7	Nothing	—
8	Nothing	—
9	Nothing	—
10	Secretion over entire dorsal half of tail	1.4 seconds
11	Secretion over entire dorsal half of tail	1.8 seconds
12	Secretion over last two-thirds of tail	2.5 seconds
13	Secretion over last one-half of tail	2.8 seconds
14	Secretion over last one-third of tail	3.5 seconds
15	Secretion only on the very tip of tail	4.1 seconds

in a serial fashion. That is, the last thoracic segment of the spinal cord, when stimulated, would cause a secretion to appear on the very last portion or tip of the tail. Whereas a more anterior segment, when stimulated, would cause secretion over a greater portion of the tail.

The total innervation of the poison glands is bound up in a nerve syncitium. This accounts for the wave of secretion being able to spread either way on the tail, the delay in the appearance of secretion over the entire tail, and the manner in which the glands are innervated when all known pathways back to the brain have been severed.

These glands appear to be protective in nature for the secretion is only released when the animal is severely traumatized.

SUMMARY

1. Twenty-two adult salamanders were used in this experiment, three for histological examinations, five for autonomic drug experiments, and the remainder for stimulation of the sectioned spinal cord.

2. The histological examination revealed nerves running among the smooth muscles of the acinus walls.

3. The autonomic drug experiments indicated that the nerves were from the sympathetic nervous system.

4. Stimulation of the sectioned spinal cord disclosed that the different levels of the thoracic and lumbar portions of the spinal cord (segments 10-15), when individually excited for a short period of time, would cause a segmental secretion on the tail.

5. Prolonged excitation of segments 10-15 will eventually cause secretion to appear on the entire dorsal surface of the tail, indicating the presence of a nerve syncitium.

6. This entire study proved that the walls of the poison skin glands in the tail of the salamander are innervated by sympathetic nerve fibers that have their cells of origin in spinal cord segments 10-15.

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The Sympathetic and Parasympathetic Nerve Fibers in the Renal Cortex of the Cat

BY

PHYLLIS D. ZWARYCH and PAUL GIBBONS ROOFE
Department of Anatomy, University of Kansas, Lawrence, Kansas

ABSTRACT: The results of the experiments with regard to the presence of sympathetic and parasympathetic nerves in the cat support the concept that both sympathetics and parasympathetics contribute to the innervation of the cat kidney. The results do not support the concept that there are sympathetic but no parasympathetic fibers in the kidney. The results also propose that nerves enter the renal cortex by following renal tubules as well as blood vessels.

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INTRODUCTION

Pappenheim in 1841 presented the first description of nerve fibers in the parenchyma of the kidney as cited by Gruber (1933). Pappenheim was able to trace nerve fibers by gross dissection down to arteries of 0.3 millimeter in diameter. Some years later Beale (1869) examined the kidneys of frogs, pigs, rabbits, newts, dogs, cats and man by prussian blue and carmine staining techniques and reported nerve filaments in relation to the arteries and tubules. Holbrook (1883) used a modified Cohnheim's gold choloride method and described rich plexuses of nerve fibers around uriniferous tubules.

Bradford (1888-9) described nerves in relation to renal blood vessels but did not discuss the arrangement with regard to the renal

tubules. Berkley (1893) considered that the intrinsic renal nerve network included nerves accompanying blood vessels ending on the adventitia of these vessels as well as between renal tubules. He observed a fine meshwork of nerve fibers around the glomeruli. Azoulay (1894-5) used Golgi and Cajal staining techniques to delineate nerve filaments accompanying and innervating the blood vessels and ending in a network among the tubules and the glomeruli. He reported nerve filaments both on and within the glomerular capsules with some filaments penetrating between capillary loops. He mentions that the cortex has a much richer innervation than does the medulla.

Probably due to the non-specific staining results thus far obtained scientists began investigating the problem of renal innervation and function by physiological experiments. Among the first physiologists to be concerned with renal innervation and function was Quinby (1916) who did his experiments on dogs using a modified transplantation technique. Under ether anaesthesia he removed the right kidney from the body thus severing completely both its blood supply and nerve supply. He then replaced the kidney and reestablished its blood supply but not its nerve supply. The opposite kidney was left untouched as a control. He noted that the immediate effect of the loss of nervous control over the experimental kidney was a period of overaction. After a lapse of time the experimentally denervated kidney reacted in a normal manner. He stated that a kidney recently deprived of its nerve supply is one without vasomotor control therefore its blood vessels are dilated. Quinby maintained that his results gave no direct indication of the possibility of a secretory function of either the vagus or the splanchnic nerves. He suggested that chemical and hormonal action of substances contained within the circulating blood, in addition to vasomotor control within the kidney, will be found adequate to explain all variations and types of normal renal functions.

Marshall and Kolls (1919) were concerned with nervous control and its relationship to renal function. They conducted a group of experiments which included the effects of unilateral excision of the adrenal gland, section of the splanchnic nerves and section of the renal nerves on the secretion of the kidney. Their results were that all three operations increased the urine output as well as caused a more dilute urine to be secreted. They stated that the

removal of the adrenal gland affected the kidney because the nerves going to the kidney in the vicinity of the excised gland had been injured.

Kaufman and Gottlieb (1931) described a nerve supply to both the renal parenchyma and the vascular network. They also noted a rich supply of nerves in the fibrous capsule of the kidney. They observed nodular, brush-like and arborized nerve endings in the kidney tissue. Nerves were observed terminating on both tubules and arteries with some fibers being traced to the capillaries ending in the glomeruli. They believed a greater number of tubular nerve fibers existed but these fibers could not be demonstrated due to the methods of staining used.

Gruber (1933) summarized from the accumulated literature and by some of his own experimentation that the kidneys are innervated by parasympathetic and sympathetic nervous elements. He proposed that the functions of the sympathetics are both vasodilatation and vasoconstriction, these actions being sufficient to explain the secretion of urine without the assumption of specific secretory nerve fibers existing in the kidney. We believed that the function of the parasympathetic fibers had not been proved satisfactorily either by physiological or pharmocological investigations.

Also from a study of the literature, and some of his research, Szabo (1948) concluded that the arterial network (including the glomeruli) and the tubular epithelium, the two most important formations of the kidney, have nervous connections. The practical significance of these facts, he points out, is that sensory fibers terminating in the capsula fibrosa and along the arteries register local pressure conditions under normal circumstances. He postulated a reflex arc whose efferent fibers cause vasoconstriction in the renal arterial network. Vasoconstriction in turn cause a decrease or possibly a loss in glomerular filtration. With regard to renal sympathectomy Szabo concluded that it is actually a periarterial sympathectomy, that is, a denervation of the kidney's arterial network. The denervation of the functional arterial network influences glomerular filtration as discussed above.

Using Bodian's Protargol method, a more specific staining technique for nerves, Harman and Davies (1949) studied the intrinsic innervation of the mammalian kidney. They found that nerves and nerve endings were more numerous than had been previously reported. They observed nerve endings on the adventitia of

blood vessels, the epithelium of the pelvis, between tubular cells and in the perivascular tissue of the glomeruli. The structure of most of the nerve terminals they noted were fusiform, club-shaped and ring-shaped. They proposed that the free nature of the nerve terminals and the character of the glomerular complex suggests an afferent mechanism thus implying that the kidney is vast sensory organ.

Christensen, *et. al.*, (1951) utilized degeneration studies to state that most of the nerves in the kidney are associated with arteries and arterioles. They supported the concept that the efferent innervation of the renal arteries, veins, and the rest of the vascular bed in the kidney is solely sympathetic, and that there are no parasympathetic nerves in the perivascular plexus within the kidney.

Physiological experiments were also conducted in order to contribute information concerning the actions of the renal nerves in relation to functioning of the kidney. Kaplan, *et al.*, (1951) showed that denervated kidney of a dog demonstrated a higher concentration of sodium and chloride in the urine flow. Block, *et al.*, (1952) demonstrated the fact that electrical stimulation of the renal nerves under optimum conditions caused sufficient renal vasoconstriction to result in the cessation of the blood flow through the kidney for a few minutes. Hoff, *et al.*, (1951) described the results of electrical stimulation of foci on the anterior sigmoid gyrus of the cerebral cortex in cats. As a result of stimulation they observed a transient elevation in blood pressure in the general circulatory system together with renal cortical ischemia. Unilateral renal denervation essentially abolished these ischemic changes in the denervated kidney during stimulation of the brain.

Mitchell (1951) conducted extensive morphological studies of the intrinsic nerves of fetal and adult human, cat, rat, macaque monkey and mouse kidneys. With a variety of techniques he stained kidney sections for both nervous and connective tissue elements. He established a table of criteria for distinguishing the nerves from the connective tissue strands. He pointed out that the existence of rich intrarenal nerve plexuses, of nerve plexuses within the glomeruli, of distinctly myelinated nerve fibers within the kidney and interarenal ganglia or nerve cells could not be confirmed. He demonstrated nerve filaments supplying both the tubules and the glomeruli. Mitchell did not distinguish sympathetic from parasympathetic nerves in the kidney.

Kuntz (1953) stated that afferent fibers of both spinal and vagal nerves traverse the renal plexus. Preganglionic sympathetic fibers traverse the splanchnic nerves passing either through the coeliac plexus or directly joining the renal plexus. He states that nerve fibers of vagal origin have been traced into the renal plexus by various investigators but these parasympathetic fibers probably do not extend into the renal parenchyma.

Maillet (1959) worked with frogs, salamanders and guinea pigs describing nerve fibers going to the tubules, to the capsule of the glomeruli and entering each glomerulus to end on the cellular membrane of the floccular capillaries. He concluded that the sympathetic role in the kidney involves glomerular control, arterial control and partial tubular control. He suggested that the parasympathetics have as their function tubular control.

The investigations cited indicate the presence of sympathetic nerve fibers in the kidney but do not establish the presence of parasympathetic nerves in the kidney. In the present investigation denervated kidneys of cats were utilized to derive more information concerning the presence of sympathetic and parasympathetic nerves in the renal cortex of cats. The absence of nerves in the denervated kidneys contrasted with the presence of nerves in the normal kidneys will establish the presence of sympathetic and/or parasympathetic nerves in the renal parenchyma. It is believed that there are parasympathetic nerves in the kidney but investigations to date have not been able to give conclusive evidence of their presence.

MATERIALS AND METHODS

Nine apparently healthy and normal male and female adult cats of approximately the same size were used for these experiments. Three of the cats were sacrificed without being subjected to any operation. An operation was performed on three cats in order to remove the right half of the coeliac ganglion and plexus. The remaining three cats were subjected to removal of a cervical segment of the right vagus nerve. The cats in which no operation was performed have their kidneys designated as normal kidneys. In the operated animals the right kidneys are designated as experimental and the left kidneys are designated as control. After sacrificing the cats, the kidneys were removed from the body, the capsula fibrosa was striped off the kidney and the kidney was cut longitudinally into symmetrical halves and immersed into ten per

cent formalin. The anaesthesia used in the necessary operations was veterinary nebutal in dosages of one milliliter per five pounds of body weight.

Samples of the kidney tissues were imbedded in Fisher tissuemat (56°-58°), sectioned at twelve to fifteen micra and mounted on glass slides. Three stains were employed to try to bring out the nervous elements; these were Holmes (1943), Brown-Vogelaar (1956) and Peters (1958). The performance of both the Holmes stain and the Peters stain was adequate for staining nerve bundles but was inadequate for staining the finer nerve fibers. The performance of the Brown-Vogelaar stain gave adequate results for the histological studies.

The purpose of choosing the coeliac plexus for removal was to cut off the major sympathetic and parasympathetic nerve supply to the kidney. The right side of the animals was chosen at random as the experimental side. The removal of the vagus from the neck, due to its relative accessibility, was preferred to removal of the vagus infradiaphragmatically. In counting the nerve fibers in a given histological area in the kidney cortex, one should theoretically find fewer fibers in the coeliac denervations than in the vagal denervations since it is cited in the literature that there are sympathetics but no parasympathetics in the renal cortex.

To remove the right half of the coeliac ganglion in the given cats, the operation commenced by entering the abdominal wall at the linea alba. The intestines were displaced to the outside of the body and kept warm and moist with a 0.9 per cent saline solution. In the three cats involved in this operation it was noted that both halves of the coeliac ganglion were closely associated. The ganglion was usually found in the mesentery proper anterior and partly dorsal to the renal artery (near its branching from the abdominal aorta) and medial to the hepatic portal vein. One half of the ganglion leading to the right side and any branches of it going to the right renal plexus were removed. The intestines were replaced and the abdominal wall was closed. After allowing two to three weeks for degeneration the animals were sacrificed. Before the kidneys were removed the right side was checked to be certain that the connections of the coeliac ganglion had not regenerated. As far as could be determined by gross inspection the connections had not been reestablished.

In the vagotomy operations an incision was made in the skin between the outlines of the sternocleidomastoid muscle and the sternohyoid muscle on the right side of the neck. After exposing

the carotid sheath in the underlying fascial planes, the vagus nerve was separated from the cervical sympathetic chain. A 1.5 to 2.0 centimeter section of the vagus nerve was excised. The structures were replaced in their normal positions and the skin was closed. Approximately four weeks were allowed for degeneration in these animals. After this time the animals were sacrificed and checked to be sure the section of the vagus had not regenerated. No regeneration was noted upon gross examination of the area.

The time allowed for maximum degeneration in the experimental cats is given as follows:

COELIAC REMOVED		VAGUS REMOVED	
Cat No.	Days	Cat No.	Days
III	19	VI	31
IV	18	VII	30
V	27	VIII	29

According to Cajal (1959) degeneration takes place in fibers of medium thickness in fifteen days and in the finest nerves in nine to ten days with degeneration occurring simultaneously along the entire length of the fiber.

The amino-silver method of Brown and Vogelaar (1956) was used to stain the kidney sections. This staining method is a modified Bodian technique used for 10 percent formalin fixed tissues imbedded in paraffin, sectioned and mounted on slides. The staining is accomplished by an amino acid-silver nitrate solution to which metallic copper strips are added. The amino acid (glycine) stabilizes the dilute silver nitrate solution. This impregnating solution is adjusted to a pH of 8.0-8.5 with normal sodium hydroxide. The slides to be stained are placed in this solution for 24-48 hours at 37 degrees centigrade. The remaining steps in the staining procedure are standard: the reduction, rinsing, gold toning, oxalic acid treatment and sodium thiosulfate treatment follow the original Bodian technique.

The silver impregnanted tissues were used to determine differences in the quantitative distribution of nerve fibers in the renal cortex. The data of Table I deal with the presence of fibers around the renal tubules; those of Table II deal with the presence of fibers around the glomeruli; while the data of Table III deal with the distribution of nerve bundles in the tissue sections. Generally speaking the studies are designed to demonstrate either the morphological differences or simularities between the normal, experimental and control kidneys. This information could contribute to the determination of the presence of parasympathetic and/or sympathetic nerves in the cortex of the cat kidney.

The fibers referred to in Table I were the black strands observed around the convoluted tubules in the renal columns of the cortex. (See photographs 7 and 8). Since the staining did not allow a distinction to be made between proximal and distal tubules no effort was made to include this information in the tables. The fibers surrounding both longitudinal and cross sections of tubules are included in the data. The fibers referred to in Table II were those observed surrounding the capsular layer of the renal corpuscle. (See photographs 5 and 6).

Random fields were brought into focus and the tubules or glomeruli and their fibers were counted and measured. All of the studies were done with an ordinary light microscope using a magnification of approximately 440 ×. The values assigned to the length of the fibers around either the tubules or the glomeruli in Tables I and II are as follows:

Strands completely around	5
Strands three-quarters around	4
Strands one-half around	3
Strands one-quarter around	2
Strands one-eighth around	1
Strands not evident	0

Each individual value was then tabulated and recorded as the total length of strands (T). The tubules or glomeruli whose strands had been measured, were tabulated and recorded as the total number of tubules (N) and the total number of glomeruli (G). The total length of the strands was divided by the total number of tubules or glomeruli to give the mean length of the strands per tubule (T/N) or per glomeruli (T/G). The per cent difference between the mean length of the strands for each pair of kidneys from the same cat was calculated and entered in the tables.

The study of the distribution of nerve bundles observed in the tissue sections is given in Table III. The information concerning the location of the observed nerve bundles and the structures to which they are adjacent is of interest in this table. (See photographs 1 and 2).

The slides used in this experiment were labeled so that the Roman numeral designates the cat number. Cats I, II and IX are the normal cats which had not been subjected to any operation. Cats III, IV and V were those whose right coeliac plexus had been removed. Cats VI, VII and VIII were those who right vagus nerve in the cervical region had been sectioned. The capital letters N,

E and C stand for normal, experimental and control, respectively. The A and B adjacent to the E and C in Cats III to VIII designates the sample of tissue cut for that given set of slides. The A and B following the N in Cats I, II and IX designates individual samples of tissue taken from the right or left kidneys of these cats. The Arabic numerals designate what slide of a given sample of tissue was used for the study. There are five to six sections of kidney tissue on each slide with most of the sections not in series.

RESULTS AND DISCUSSION

Three cats were employed for each of the groups of treatment, with a total of nine cats being used in these experiments. Three cats were used for each treatment for the purpose of giving convincing results than would be obtained by using a lesser number of animals. The right kidney of each cat was compared with its left kidney. The data collected for all nine animals are presented in Tables I, II and III. Panel A in the three tables includes the data pertinent to the normal cats which had not been subjected to an operation. Panel B in all three tables includes data related to the cats which had their coeliac ganglion and plexus removed. Panel C in all three tables includes data related to the cats which had a cervical segment of their vagus excised.

In Panel A of Table I there is a per cent difference in the mean length of strands observed per tubule between the right and left kidney of each of the normal cats. The individual values ranged from 3.50 per cent to 9.18 per cent. Since all of these values are less than ten per cent they may be considered as normal variations from one animal to another. Panel B of Table I is concerned with the per cent decrease of the mean length of fibers between the right and left kidney of the cats that had undergone the operation for removal of the right coeliac. The right kidneys showed a per cent decrease in the mean length of strands per tubules from the left kidney in all three cases. The per cent decreases ranged from 17.30 per cent to 25.46 per cent. The low value (17.30 per cent for Cat III) is nearly twice the per cent difference of the highest value for the normal cats (9.18 per cent for Cat IX). The highest value for the coeliac denervated cats (25.46 per cent for Cat V) is nearly three times the value of the highest normal cat (9.18 per cent for Cat IX). The lowest value for the normal cats (3.50 per cent for Cat I) compared to the highest value of the experimental cats (25.46 per cent for Cat V) shows the per cent decrease in

the experimental kidneys to be eight times as much as the per cent difference in the normal kidneys. In comparing the right experimental kidney to the left control kidney, the kidneys of Cats III, IV and V show at least a reduction of two times and at most a reduction of eight times the per cent difference between the right and left kidneys of normal Cats I, II and IX.

Panel C of Table I is concerned with the per cent decrease of the right experimental kidney from the left control kidney in the cats that had undergone the operation for removal of a cervical segment of the right vagus nerve. The right kidney shows a per cent decrease in the mean length of strands per tubules from the left kidney in all three cats. These per cent decreases ranged from 22.80 per cent to 36.94 per cent. The lowest value (22.80 per cent for Cat VII) for the experimental cats is more than two times the per cent difference of the highest value for the normal cats (9.18 per cent for Cat IX). The highest value for the vagal denervated cats (36.94 per cent for Cat VI) is four times the highest value (9.18 per cent for Cat IX) for the normal cats. The highest value of the vagal denervated cats (36.94 per cent for Cat VI) is thirteen times the lowest value (3.50 per cent for Cat I) for the normal cats. In comparing the per cent decreases of the mean length of strands per tubule between the experimental and normal animals, the right kidneys of the experimental cats show a reduction of two to thirteen times the difference between right and left kidneys of normal cats in the mean length of strands per tubule.

The mean length of strands per tubule was effectively decreased in the right experimental kidneys of all three cats that had their right coeliac plexus removed and in the right experimental kidneys of all three cats that had a cervical segment of their right vagus nerve removed. This decrease in the mean length of strands per tubule is not attributed to a loss of connective tissue elements around the tubules but to the loss of nerve fibers. If this loss represented a connective tissue loss, this would be of extreme interest due to the fact that there is no great loss of connective tissue resulting from the denervation of an organ. The data showed that removal of the right coeliac plexus and the right cervical vagus results in degeneration of some, if not most, of the nerve fibers around the renal cortical tubules. The conclusion derived from the data of Table I is that there are nerve fibers around the renal tubules that have originated from the coeliac plexus and the vagus nerve.

TABLE I.—A Comparative Study of the Fibers Observed Around the Tubules in the Cortex of Cat Kidney

SLIDE NUMBER	T	N	T/N	Per cent decrease
PANEL A: NORMAL CATS				
I–NA–1, 2	706	225	3.14	3.50
I–NB–5, 6	383	123	3.03	
II–NA–2, 5	340	117	2.91	6.43
II–NB–2	246	79	3.11	
IX–NA–6	338	115	2.94	9.18
IX–NB–1	353	132	2.67	
PANEL B: COELIAC DENERVATED CATS				
III–EA–2, 3	621	317	1.96	17.30
III–CA–1, 2	670	283	2.37	
IV–EA–5	193	89	2.17	24.39
IV–CA–5	162	56	2.87	
V–EA–5	287	102	2.81	25.46
V–CB–4	617	161	3.77	
PANEL C: VAGECTOMIZED CATS				
VI–EA–3	244	144	1.69	36.94
VI–CA–3	332	139	2.68	
VII–EB–2	376	146	2.37	22.80
VII–CA–3	621	202	3.07	
VIII–EB–2	404	138	2.93	30.07
VIII–CA–3	699	167	4.19	

In Panel A of Table II there is a per cent difference between the right and left kidneys of each of the normal cats in the mean length of strands observed per glomerulus. These per cent differences ranged from 6.97 per cent for Cat I to 10.24 per cent for Cat II. These values are ten per cent or less and one can expect such a fluctuation to represent normal variation among individuals. Panel B of Table II shows a per cent decrease in the mean length of strands per glomerulus of the right experimental kidney from the left control kidney in all three cats which had undergone an operation for removal of the right coeliac ganglion and plexus. These values ranged from 17.55 per cent to 26.96 per cent. The lowest value (17.55 per cent for Cat V) in the experimental cats is almost two times the highest value (10.24 per cent for Cat II) for the normal cats. The highest value for the experiment cats (26.96 per cent for Cat III) is nearly three times the highest value (10.24

per cent for Cat II) for the normal cats. The highest value for the experimental cats (26.96 per cent for Cat III) is nearly four times the lowest value (6.97 per cent for Cat IX) for the normal cats.

In Cats III, IV and V the per cent decreases from the left control kidneys to the right experimental kidneys are two to three times the per cent differences between the right and left kidneys of the normal cats. The facts show there had been removal of nerve fibers around the glomeruli of the renal cortex in the right coeliac denervated cats since the mean length of strands observed per glomerulus was effectively decreased in the right kidneys of these coeliac denervated cats. This decease in the mean length of strands around the glomerulus is not attributed to a loss of connective tissue elements but is attributed to a loss of nervous tissue elements around the glomerulus. If this were a connective tissue loss this would be of extreme interest due to the fact that one does not usually find a loss of connective tissue as a result of denervation of an organ.

In Panel C of Table II a per cent decrease in the mean length of strands around the glomerulus from the left control kidney to the right experimental kidney is evident for Cat VI of the right cervically vagotomized cats. This value is 27.14 per cent. The per cent decreases noted for Cats VII and VIII were ten per cent or less which is within the range of normal variation. Cat VI shows a per cent decrease (27.14 per cent) which is comparable to the highest value (26.96 per cent for Cat III) of the per cent decreases in the cats in Panel B of Table II.

The data of Table II showed that removal of the right coeliac plexus results in degeneration of some of the nerve fibers around the glomeruli. Due to the contradictory results concerning the removal of the right cervical vagus, the presence or absence of nerve fibers from the right vagus around the glomeruli could not be determined. The conclusion derived from Table II is that there are nerve fibers around the renal glomeruli that have orignated from the coeliac plexus. No significant statement can be made regarding the absence or presence of fibers which originated from the right vagus nerve around the glomeruli at this time.

Table III is concerned with the mode of entry of nerve bundles into the renal cortex. The total number of nerve bundles observed in the tissue sections of the normal, experimental and control kidneys was sixty-five. Of these five were observed in the medullary

TABLE II.—A Comparative Study of the Fibers Observed Around the Glomeruli in the Cortex of Cat Kidney

SLIDE NUMBER	T	G	T/G	Per cent decrease
PANEL A: NORMAL CATS				
I–NA–1	311	101	3.08	8.76
I–NB–5	247	88	2.81	
II–NA–2	132	52	2.54	10.24
II–NB–2	162	71	2.28	
IX–NA–6	183	71	2.58	6.97
IX–NB–1	252	105	2.40	
PANEL B: COELIAC DENERVATED CATS				
III–EA–1, 4	430	201	2.14	26.96
III–CB–1, 2	396	135	2.93	
IV–EA–4, 5	695	256	2.72	21.38
IV–CA, CB–5	1173	399	3.46	
V–EA–5, –EB–3	643	217	2.96	17.55
V–CA, CB–4	876	244	3.59	
PANEL C: VAGECTOMIZED CATS				
VI–EA, EB–3	679	275	2.47	27.14
VI–CA, CB–3	858	253	3.39	
VII–EA–6, –EB–2	597	192	3.11	10.11
VII–CA, CB–3	948	274	3.46	
VIII–EA, EB–2	806	233	3.46	8.71
VIII–CA, CB–3	780	206	3.79	

tissue and sixty were observed in the juxtamedullary tissue. Of all sixty-five of the nerve bundles observed, thirty-two were adjacent to blood vessels and thirty-three were adjacent to renal tubules. Most of the nerve bundles noted in the juxtamedullary region of the kidney were observed in the renal columns rather than in the medullary rays. The significance of the data collected in Table III is that nerve bundles enter the renal cortex via blood vessels and between tubules apparently with equal frequency in the kidneys of both the coeliac and vagal denervated cats.

The coeliac ganglion in the cat, according to Reighard and Jennings (1961), contains postganglionic neurons which synapse with some of the preganglionic fibers from the greater and lesser splanchnic nerves. The postganglionic fibers from the coeliac ganglion are accompanied by fibers from the vagus nerve which also sends a supply of fibers to the coeliac plexus. Some of these vagal and coeliac plexus fibers then proceed to the renal plexus to

TABLE III.—Distribution of Nerve Bundles in the Control and Experimental Kidneys

SLIDE NUMBER	Number of observed nerves	Location of bundles	Bundles adjacent to:	
			Blood vessels	Renal tubules
PANEL A: NORMAL CATS				
I–NA–2	3	1 medullary 2 juxtamedullary	2	1
I–NB–2	5	5 juxtamedullary	3	2
PANEL B: COELIAC DENERVATED CATS				
III–EA–4	1	1 medullary (hilus)		1
III–CB–3	1	1 juxtamedullary	1	
IV–CA–5	5	1 medullary 4 juxtamedullary		5
IV–CB–5	8	8 juxtamedullary	3	5
V–EA–5	1	1 juxtamedullary		1
V–EB–3	4	4 juxtamedullary	2	2
V–CA–4	1	1 juxtamedullary		1
V–CB–4	4	4 juxtamedullary	3	1
PANEL C: VAGECTOMIZED CATS				
VI–EA–3	6	6 juxtamedullary	2	4
VI–CA–3	6	5 juxtamedullary 1 medullary	1	5
VI–CB–3	4	1 medullary 3 juxtamedullary	2	2
VII–EB–2	2	2 juxtamedullary	2	
VII–CA–3	2	2 juxtamedullary	1	1
VII–CB–3	4	3 juxtamedullary 1 juxtamedullary (hilus)	4	
VIII–EA–2	2	2 juxtamedullary	2	
VIII–EB–2	1	1 juxtamedullary	1	
VIII–CA–3	3	3 juxtamedullary	2	1
VIII–CB–3	2	2 juxtamedullary	1	1
TOTALS	65	5 medullary 60 juxta-medullary	32	33

supply the kidney. Kuntz (1953) points out that there may be vagal fibers reaching the renal plexus by some other route than via the coeliac plexus.

In our experiments the results show that sympathetic and parasympathetic fibers are present around renal cortical tubules as concluded from the data of Table I. Table II shows that there are sympathetic fibers present around the glomeruli but the presence or absence of parasympathetic fibers could not be definitely determined. Table III shows that nerve bundles enter the renal cortex via blood vessels and renal tubules with equal frequency.

In the right coeliac denervated cats (III, IV and V) no attempt was made to distinguishd parasympathetic fibers from sympathetic fibers passing through the coeliac plexus. There might be some interchange of fibers between the right and left coeliac ganglia but a great interplay of fibers was not observed in the animals before removal of these plexuses. In the right vagotomized cats (VI, VII and VIII) no attempt was made to determine the contributions of the left vagus nerve to the kidneys. Experiments on the right vagus nerve showed that it contributed to the innervation of the kidneys. Considering those kidneys that were functionally controlled by parasympathetic innervation, one would naturally suppose that right vagal fibers would enter the right renal plexus and left vagal fibers would enter the left renal plexus. However, in development there might well be some interchange from one side to the other.

The results of these experiments with regard to the presence of sympathetic and parasympathetic nerves in the cat kidneys seem to support Gruber's (1933) concept that the kidneys are innervated by both sympathetic and parasympathetic nerves. The results seem to support Maillet's (1959) hypothesis that the sympathetics are involved in glomerular and partial tubular control and that the parasympathetics are involved in tubular control. The results are in opposition to Christensen, *et al.* (1951) who maintained the concept that the kidney is solely sympathetic with no parasympathetic contributions being present in the renal parenchyma. The results concerning the equal frequency of nerve bundles observed adjacent to blood vessels and renal tubules also is in opposition with Christensen, *et al.*, (1951) who proposed that nerves enter the renal cortex only along the arterial system.

We wish to point out that the use of three cats for each experimental group, that is, normal, coeliac denervated and vagal

denervated, does not give enough information for statistical evaluation. The data collected in these experiments is not sufficient to make any final conclusions but does give convincing evidence of a definite trend regarding the presence of symathetic and parasympathetic nerves in the renal cortex of the cat.

SUMMARY AND CONCLUSIONS

Silver impregnanted tissues were used for the purpose of determining the presence of sympathetic and parasympathetic nerve fibers in the cortex of the cat kidney. The tissues were obtained from normal and experimental animals. Both right and left kidneys of three cats which had not been operated upon were used as normal controls. Three cats were operated upon for the removal of the right coeliac ganglion and plexus and three other cats were operated upon for removal of a cervical segment of the right vagus nerve. The right kidney of each of these cats was designated as the experimental kidney and the left kidney of each of these cats was designated as the control kidney.

Removal of the coeliac ganglion severed the major source of sympathetic nerves (greater and lesser splanchnic postganglionics) to the renal plexus. Removal of the coeliac ganglion also included severing some parasympathetic fibers of the vagus nerve. Removal of the cervical segment of the vagus nerve severed a major source of parasympathetic fibers to the kidney.

The data collected in the experiments presented in this study contributed the following information:

1. There are both sympathetic and parasympathetic fibers in the cortex of the cat kidney as determined by denervation studies of nine cats.
2. Sympathetic and parasympathetic fibers seem to be present in relation to the renal tubules of the cortex of the cat.
3. Sympathetic fibers seem to be present around the glomeruli of the cortex but no significant statement can be made about the presence of parasympathetics around the glomeruli.
4. Nerve bundles are observed adjacent to blood vessels and renal tubules in the cat kidney apparently with equal frequency. This demonstrates that nerves follow both the blood vessels and renal tubules into the cortex of the kidney.

This study did not elaborate upon nor refute the heretofore cited facts that many sympathetic fibers traverse the coeliac and renal plexuses to arrive at the kidney, that parasympathetic fibers travel via the vagus nerve to the coeliac and renal plexuses to arrive at the kidney, that the normal contributions to the renal plexus are from the following structures:

1. chiefly from the coeliac plexus
2. second and third lumbar segments of the sympathetic trunk
3. aortico-renal ganglion
4. aortic plexus

The results of the experiments with regard to the presence of sympathetic and parasympathetic nerves in the cat support the concept that both sympathetics and parasympathetics contribute to the innervation of the cat kidney. The results do not support the concept that there are sympathetic but no parasympathetic fibers in the kidney. The results also propose that nerves enter the renal cortex by following renal tubules as well as blood vessels.

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KEY TO ABBREVIATIONS

A	arteriole
BV	blood vessel
DB	dichotomous branching of the nerve fiber
G	glomerulus
MR	medullary ray
N	nerve fiber
NB	nerve bundle
RC	renal column
S	black strand

PLATE I

Innervation of Renal Cortex in the Cat

FIG. 1—Nerve bundle adjacent to a blood vessel in the juxtamedullary tissue. 100 ×

FIG. 2—Nerve bundle between tubules of the renal columns in the juxtamedullary region. 440 ×

FIG. 3—Unidentifiable black strands along an arteriole leading to a glomerulus in the cortical tissue. 100 ×

FIG. 4—Black strands around blood vessels of the cortex which could not be identified as nerve fibers without doubt. 100 ×

PLATE I

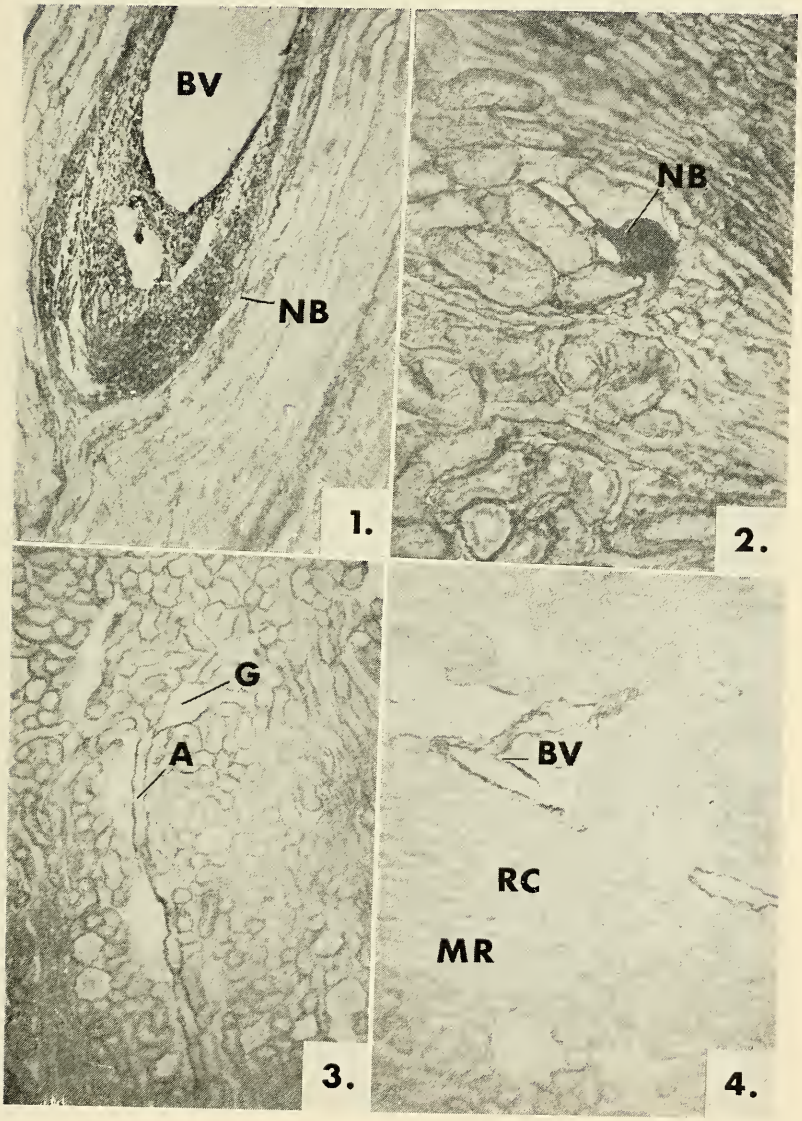
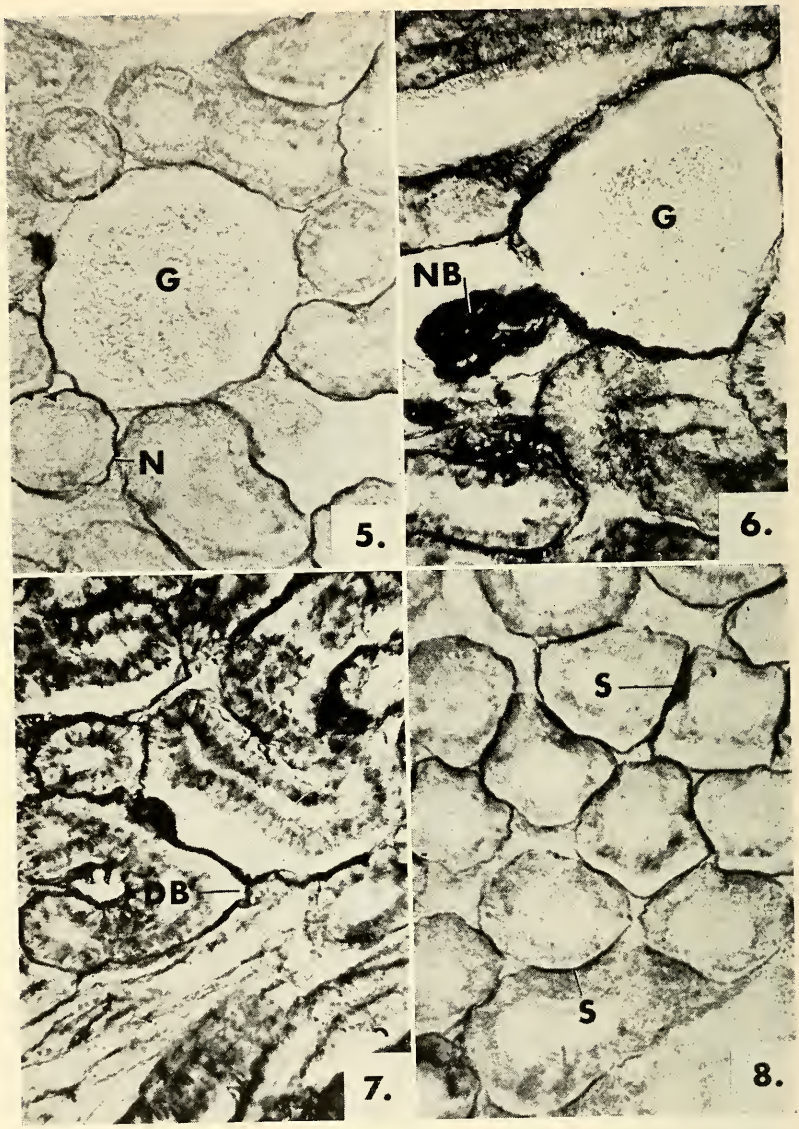


PLATE II



Innervation of Renal Cortex in the Cat

FIG. 5—Glomerulus in cortex with nerve partly surrounding it and branching to adjacent tubules. 440 ×

FIG. 6—Nerve bundle branching to adjacent glomerulus. 440 ×

FIG. 7—Dichotomous branching of nerve fiber between renal tubules of cortex. 440 ×

FIG. 8—Black strands between cortical tubules which were measured and tabulated for Table I. 440 ×

THE UNIVERSITY OF KANSAS
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The Serpents of Thailand and Adjacent Waters

BY

EDWARD H. TAYLOR

ABSTRACT: This review of the serpents of Thailand is based largely on the herpetological collections made in the years 1957-1961 in Thailand and adjoining countries by the author. This fauna is treated under ten families, 58 genera, 159 species and subspecies; certain unnamed varieties are discussed.

Many of the emendations of generic names have been disregarded in accordance with an interpretation of the recent laws of nomenclature and *Aplopeltura, Gerarda, Erpeton, Calliophis, Aipysurus* are used instead of *Haplopeltura, Gerardia, Herpeton, Callophis* and *Aepyurus.*

The most recent listing of Thai snakes is that of Taylor and Elbel (1958) in which 129 names appeared; certain ones have been dropped from the list and the following names are added:

Typhlops khoratensis Taylor
Typhlops trangensis Taylor
Typhlops diardi Schlegel
Typhlops siamensis Günther
Python curtus Schlegel
Sibynophis melanocephalus Gray
Gonyosoma floweri (Werner)
Gonyosoma jansenii elegans (Werner)
Elaphe taeniura ridleyi (Butler)
Oligodon cinereus swinhonis (Günther)
Oligodon cinereus multifasciatus (Jan)
Oligodon cyclurus superfluens subsp nov.
Oligodon cyclurus smithi (Werner)
Liopeltis baliodeirus cochranae Taylor
Calamaria leucocephala Duméril, Bibron and Duméril
Calamaria uniformis M. Smith
Boiga drapiezii (Boie)
Boiga dendrophila melanota (Boulenger)
Boiga nigriceps (Günther)

Boiga jaspidea Duméril, Bibron and Duméril
Boiga cynodon var.
Calliophis macclellandii macclellandii Reinhardt
Calliophis maculiceps malcolmi Taylor
Calliophis gracilis Gray
Astrotia stokesii (Gray)
Trimeresurus erythrurus Cantor
Trimeresurus sumatranus (Raffles)
Trimeresurus stejnegeri K. Schmidt

No evidence is at hand for the retention of *Enhydris chinensis* (Gray) in the list. *Trimeresurus puniceus* (Boie) of the former list is the same as *Trimeresurus kanburiensis* M. Smith. *Natrix modesta* (Günther) is dropped, and *Boiga d. dendrophila* of the former list is the same as *Boiga d. melanota* (Boulenger).

Most of the species considered are redescribed from Thai specimens and 125 figures, mostly photos of entire specimens in black and white, illustrate more than one hundred of the forms.

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INTRODUCTION

METHODS

The general plan of this work follows that of the "Amphibians of Thailand," published in 1962 and "The Lizards of Thailand," published in 1963. Since those works were completed the new International Rules of Nomenclature and Procedure has been published. In consequence, in this work on the serpents* I have attempted to follow the proposed regulations, such as the use of the colon after authors names in the listing of literature, and the recording of type-localities for original names and synonyms where these are known.

The spelling of Thai geographic names has caused no small difficulty since the available maps show great diversity. This is because the Thai alphabet has many more characters available than the English and there maybe no consensus as to the proper spelling of the Thai word and certainly none for the proper method of its transliteration into English. In reporting the distribution of the various species, I have listed, for the most part, only the Changwat or province, rather than publish a catalogue of all the specimens collected. This of course is a measure for economy. In the spelling of the provincial names I have used that of the U. S. Army Gazetteer of 1944. I have attempted to follow the same criterion for other geographic names but there are perhaps some inconsistencies in the spellings. One other difficulty has been the fact that the geographical divisions have themselves been changed. Thus formerly much of the present southern part of peninsular Thailand consisted of Pattani province which was further divided into several smaller states. These have now ceased to exist and the former Pattani now consists of three changwats, Pattani, Narathiwat and Yala, and perhaps a part of Songkhla.

The specimens in the collection of Chulalongkorn University largely brought together by me form the basis for this study, and all numbers unless otherwise designated belong to that collection. In a number of cases other specimens have been photographed or described, and abbreviations, to designate the source of the specimen, have been used. These abbreviations are as follows:

ANSP	Academy of Natural Sciences, Philadelphia.
AMNH	American Museum of Natural History, New York.
B.L.	Private collection of Dr. Boonsong Lekagul, Bangkok, Thailand.
B.M.	British Museum (Natural History) London.
C.U.	Chulalongkorn University (recent acquisitions) Bangkok, Thailand.

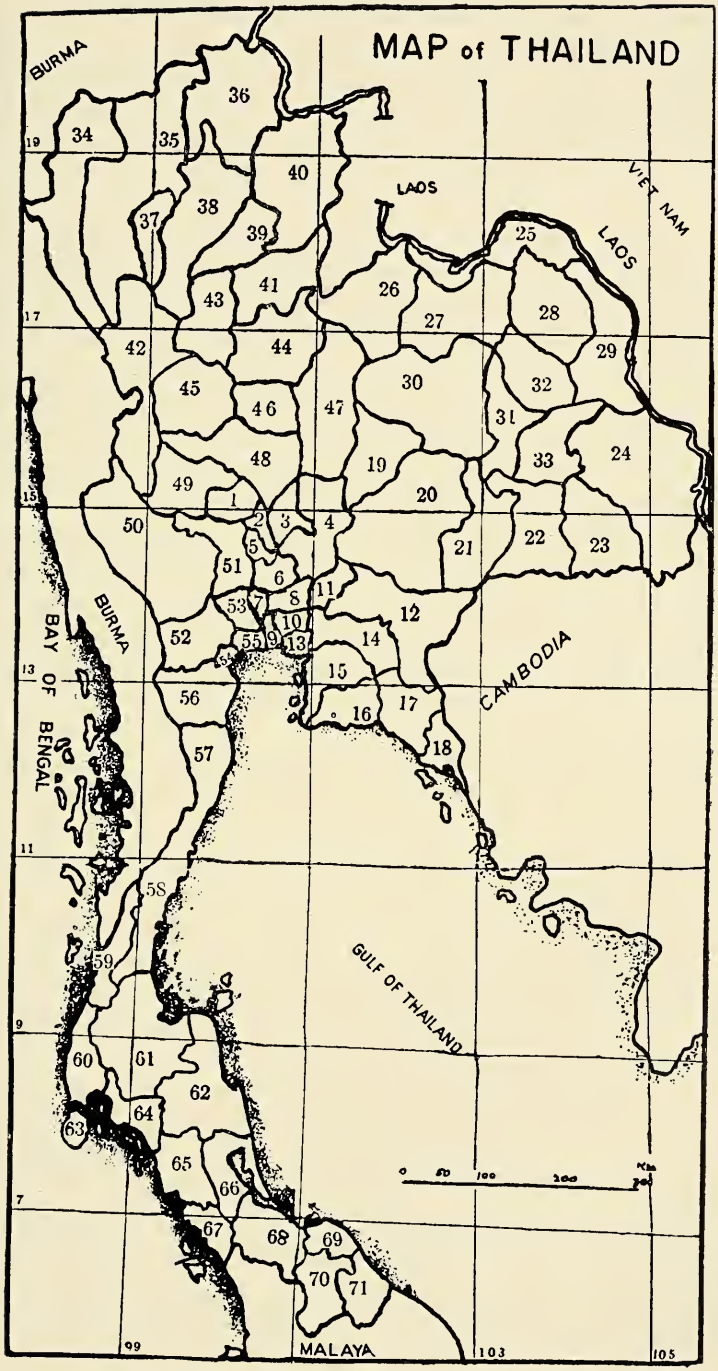
* The names serpent and snake are regarded as synonyms and used interchangeably.

EHT-HMS	Edward H. Taylor-Hobart M. Smith collection, Lawrence, Kansas.
KUMNH	Kansas University Museum, Lawrence, Kansas.
M.S.	Private collection of Malcolm Smith, largely in the British Museum (Natural History) London.
P.K.	Private collection of Nai Prayoon Kananuracks, Na Pradoo, Pattani, Thailand.
USNM	United States National Museum, Washington, D. C., U. S. A.

LIST OF THAI PROVINCES

(Corrected spellings as used by the U. S. Army Gazetteer, 1944)

1. Chainat
2. Sing Buri
3. Lop Buri
4. Sara Buri
5. Ang Thong
6. Ayutthaya
7. Nonthaburi
8. Pathum Thani
9. Thon Buri
10. Phra Nakhon (Bangkok)
11. Nakhon Nayok
12. Prachin Buri
13. Samut Prakan
14. Chachoengsao
15. Chon Buri
16. Rayong
17. Chanthaburi
18. Trat
19. Chaiyaphum
20. Nakhon Ratchasima (Khorat)
21. Buriram
22. Surin
23. Khu Khan (Sisaket)
24. Ubon
25. Nong Khai
26. Loei
27. Udon Thani
28. Sakon Nakhon
29. Nakhon Phanom
30. Khon Kaen
31. Maha Sarakham
32. Kalasin
33. Roi Et
34. Mae Hong Son
35. Chiang Mai
36. Chiang Rai
37. Lamphun
38. Lampang
39. Phrae
40. Nan
41. Uttaradit
42. Tak
43. Sukhothai
44. Phitsanulok
45. Kamphaeng Phet
46. Phichit
47. Phetchabun
48. Nakhon Sawan
49. Uthai Thani
50. Kanchanaburi
51. Suphan Buri
52. Rat Buri
53. Nakhon Pathom
54. Samut Songkhram
55. Samut Sakhon
56. Phet Buri
57. Prachuap Khiri Khan
58. Chumphon
59. Ranong
60. Phangnga
61. Surat Thani
62. Nakhon Si Thammarat
63. Phuket
64. Krabi
65. Trang
66. Phatthalung
67. Satun
68. Songkhla
69. Pattani
70. Yala
71. Narathiwat



MAP No. 1. Provinces (Changwats) of Thailand. The numbers refer to the numbered list of provincial names, and have no significance in themselves.

In preparing the synonymies and listing the literature no attempt has been made to make them complete.

The figures in practically all cases are photographs of preserved specimens submerged in a clear liquid. The actual size of the specimen is given in the caption.

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GENERAL CONSIDERATION OF THE SERPENTES

Body form: It is somewhat astonishing to discover that the body form of serpents is invariably serpentiform! This is remarkable since we find that the Serpentes were developed from quadrupedal ancestors.

Why have they been cast in so limited a variety of molds? Seeking for a reason one might draw on modern cognate happenings in the lizards, where representatives of certain families are seemingly acquiring bodies cast from molds somewhat similar to those of the serpents. This we may interpret as resulting from food competition among species, usually between two related forms, and the more successful one becoming dominant and extinguishing the other competitor by utilizing the available food; that is, unless the latter can find new sources of food which it may obtain without strong competition or for which it may compete successfully. Perhaps the subterranean food sources, the ones nearest at hand, are consequently more desirable than new food source at a greater distance.

In these circumstances the most successful of species, so dominated, will be those whose environments select mutations involving the reduction of appendages, since this type of mutation would appear to have the highest survival value for species foraging below the surface, seemingly permitting subterranean locomotion and food-finding with greater ease. Often the only species of such a lizard group genus to survive, will be one that approaches the serpentine form most closely, that is, with total or almost total loss of the paired appendages, and a serpentine body.

If we consider the serpent as having undergone such an evolution, we must further postulate that at some time in the past the competitor itself has been eliminated and the animal has secondarily emerged from its subterranean habitat and has in this form of a four-time-amputee, reconquered many of the food sources of the earth. The serpents now are seemingly able to compete

for food in most parts of the world; able to move about from sea level to elevations of 3000 meters or more; to climb trees and assume an arboreal habitat; to compete with fresh water feeders in an aquatic medium. They have even entered the sea to compete successfully there with marine animals. Some even have secondarily gone underground, becoming burrowers, or occupying caves. They have redistributed themselves from Hudson bay to Tierra del Fuego, from Scandinavia to Tasmania. Perhaps the modern serpent is one of the greatest of all evolutionary miracles!

Tails: Practically all serpents have retained tails. Among the genera of the TYPHLOPOIDAE, LEPTOTYPHLOPIDAE and ANILIIDAE the tails are greatly reduced in length, occupying only a few millimeters of the total length. These are for the most part burrowing snakes and the tail may bear a terminal downward-directed spine for aid in locomotion.

In arboreal snakes several types of tails are known, occasionally comprising as much as a third or more of the total length. This presumably serves, through the added length, as a survival character in preventing falls. If an arboreal form has a short tail it may become a grasping organ and this grasping ability likewise may serve as a survival character. Thus an arboreal snake attempting to strike at prey may find that the grasping ability of the tail will keep the body from being thrown completely from a limb, or the tail of greater length may prevent too great a fall by stretching over branches should it begin to fall.

In the males the hemipenes are housed in the base of the tail. In the case of certain American crotalid snakes a groups of noise-making scales are retained as a rattle at the end of the tail. In a few cases a small tail, brightly colored, is moved seemingly for the purpose of attracting small animals on which the tail owner feeds. Among American snakes many species of other families "rattle" the tail in leaves or on some surface to produce a sound not too unlike the rattle of the Crotalid.

Body covering: Since serpents inherited a covering of armour over the body in the form of horny or keratinous scales, it would appear that it has never been wholly lost and that such mutations, as may have occurred toward loss of this armour-plate, have been lethal, since no such forms have survived. However there have been ample change in this covering and often the present arrangement of scales, their numbers, size, ornamentation, position, serve as indicators of relationships among species and groups of species.

Some of the most striking scale variants are as follows:

1. All body-scales are practically the same size and shape, one or two transverse rows corresponding to a vertebra (perhaps three in some cases), the number of longitudinal rows varying considerably. The scales of this type are of little service in locomotion except that often a terminal spike is present which allows the body to push itself forward (Typhlopidae).

2. Differentiation of the scales so that a series of widened ventral develops that may aid in locomotion; transverse dorsal scale series may be arranged obliquely as in many Colubrid snakes.

3. A secondary reduction in the size of the ventral series (or its complete or partial loss) as in most marine serpents (Hydrophiidae).

4. One of the most remarkable and unusual conditions is the presence of specialized groups of enlarged platelike dorsal scales mixed with smaller ones (as occurs frequently in lizards but rarely in snakes (*Xenodermus*).

5. An excess of decoration of individual scales associated with a great number of longitudinal scalerows (130-150) (*Acrochordinae*).

6. The presence of small or granular scales on head while the body-scales retain the typical colubrid form (*Crotalidae*).

7. Variation in the arrangement of scales so that they tend to overlap (imbricating) or separating so that they lie side by side (juxtaposed as in many sea-serpents) or separated still further so that areas of bare skin intervene between scales (*Bitia*).

8. Specialization of individual scales such as the presence of apical pits; development of spines or tubercles on scales throughout the body or the reduction of this tuberculation to a small area on the sides in the region of the vent in males.

9. The development of glandular pits in scales, such as in the labials of the Boidae.

10. The presence of an extremely fine grill-work on the unattached undersurface of the scales of many Typhlopidae; of keels and minute sculpturing or striae on the dorsal surface of the scales of many species.

11. Shape of the individual scales may vary and these may be rounded, hexagonal, pentagonal, quadrangular, arrow-shaped, slender, pointed, truncate behind, or granular.

12. The number of scalerows on the body is an important character and the number may vary at different points on the body. In a few snakes the number may remain practically the same throughout the body or there may be a slightly larger number anteriorly on the neck the same number throughout the greater part of the body and the reduction of two to four scalerows posteriorly. This reduction may come about through the dropping out of rows, or the fusion of two rows. Occasionally there is a large increase in number of scalerows from neck to the middle of the body and differences in count of 10 to 20 or more may obtain (some aquatic snakes).

In most serpents there is an uneven number of scalerows (the ventral row not counted). However, in the genus *Ptyas* some members of the genus have the uneven number, another species may have an uneven number anteriorly and an even number posteriorly, or, in one species, the number may be even throughout.

The actual number of scalerows varies from 8 to 10 (in *Chironius*), up to 150 (in *Acrochordus*).

Shedding: As in many animals the outermost portion of the skin or scales is not given food by the blood and soon dies but remains as a protective covering even though lifeless. This at regular times becomes loose and is removed from the body. While all Sauria and Amphibia shed this layer, the method of shedding varies. It is often, if not usually eaten in the Amphibia and Sauria, the mouth often serving as an aid in its removal. In serpents, when this skin-layer is ready to be shed, it is loosened about the mouth, and removed by moving the body past a rough surface which tends to hold the skin, permitting the animal actually to crawl out of the skin. To my knowledge this is never eaten by them. The number of times that shedding takes place in a year varies with the species and with the latitude in which the animal has its habitat.

Body glands: Malcolm Smith and Nakamura (1935) have pointed out the presence of nucho-dorsal skin-glands on the nuchal region of snakes in the genera* *Rhabdophis* (*Natrix*), *Macropisthodon* and *Balanophis*. These may be confined to the nuchal region or may extend the length of the body on the dorsum.

The function of the secretion of the glands has not been determined beyond question, the most likely probability being that it functions in courtship or mate-finding. Other odoriferous glands are to be found near the cloacal opening.

Head glands: Various glands in the cephalic region are present in serpents. These subsquamate glands are occasionally in evidence externally through transparent scales. Series of these can be seen in *Typhlops braminus*, seemingly following the sutures of the anterior head-scales. The large parotid gland in *Boiga* is often visible externally below the eye as a yellowish or whitish spot, sometimes a little elevated.

Most of the head glands open into the mouth. Smith records a supralabial, a parotid, a premaxillary or intermaxillary, an inferior labial, a nasal, an anterior temporal, a Harderian and a sublingual. Certain of these are the equivalent of salivary glands.

The parotid gland produces a secretion that is discharged into the mouth or in the case of poisonous snakes, into sacs at the base of the enlarged grooved or tubular teeth. The secretion is the

* Dr. Smith's key of these snakes (1943, p. 284) is somewhat misleading. The section B, states "no nuchal gland or groove" while below are listed two forms, *callichroma* and *nigrocincta* both having nuchal glands, as correctly stated on a preceding page (15).

venom or poison that, injected into an animal, has a deleterious effect, death often resulting from physiological happenings after the injection has been made. Usually the specific effect of such an injection is dependent on the quantity of venom injected. The deadliness of venoms varies considerably but in large part it is due to the size of the injecting apparatus, the size of the snake, and especially in the bulk of the victim bitten. A venom of a species, capable of killing its prey, might be practically harmless to man.

Danger from snakebite has always been greatly exaggerated as have often the statistics pertaining to the same. While the poison gland is usually confined to the head region, snakes of the genus *Maticora,* of which several representatives occur in Thailand, have a poison gland extending some distance back into the body cavity—sometimes as far back as the heart. The effect of the venom of this snake however is not known, but *Maticora bivirgata* reaches a length of six feet and is large enought to pose a definite threat to man.

Almost all the sea-serpents have a deadly poison but they may be handled, most of them seemingly unaware that biting is a means of self protection, or attack. While they may be exceedingly common in waters about coastlines the number of deaths reported from their bites is amazingly small.

The behavior of Kraits (genus *Bungarus*) is especially significant. A Gurka from Nepal when asked the name of the Krait said it was "'good snake' because it *never* bites; but if it does it kills you." I have teased the common Thai Krait, *Bungarus fasciatus,* which may reach a length of two meters, but even when teased or given rough treatment designed to anger or even injure the snake it will keep placing its snout against the earth refusing to strike or bite, often hiding its head with the folds of the body. Malcolm Smith (1943 p. 413) states that there is no published record of death of human beings, or even of human beings being bitten by this form. He further states that the Burmese maintain that it is not a poisonous serpent!

Cobras however are more excitable, and seem to be willing to use the venom for protection or as a weapon of aggression. A rather large specimen of the black cobra caught at Bang Saen was brought alive to Bangkok. Certain friends wished photographs of the snake. I insisted that they should wear eye-glasses as possible protection for their eyes, since this form is a "spitting cobra." The snake was

turned loose on a lawn and teased, so that it assumed the erect threatening posture and actually came forwards towards me to attack as I walked backward. The photographs taken, the snake was replaced in its container; but a second time when loosened for further photographs it assumed the posture and came forward to attack, spitting the venom into the air. This reached my face as a fine mist as was evident from the surfaces of my eye-glasses.

Of the Thai snakes the following groups of snakes are known to be poisonous:

Subfamily BOIGINAE, with the genera *Boiga, Dryophis, Chrysopelea, Psammophis and Psammodynates.* The poisons are usually not regarded as dangerous to man. Quantities injected into small animals may cause their death.

Subfamily HOMALOPSINAE including the genera *Enhydris, Homalopsis, Cerberus, Bitia, Gerarda* and *Erpeton.* These snakes have enlarged grooved fangs and poison, but must not be considered dangerous to man.

Family ELAPIDAE, with the genera *Naja, Bungarus, Dendraspis, Calliophis* and *Maticora.* Of these genera *Dendraspis, Bungarus* and *Naja* are known to be deadly to man. This does not necessarily mean that every bite produces death since the quantity of venom injected is an important factor in the outcome of the bite.

Family HYDROPHIIDAE with the genera *Hydrophis, Astrotia, Kerilia Kolpophis, Praescutata, Enhydrina, Acalyptophis, Thalassophis, Microcephalophis, Pelamis* and *Lapemis* are known to have deadly poison but relatively few deaths in man are reported from such bites. In no cases are snakes of this group aggressive, and very few of them will bite even when provoked. However, extreme care should be taken in handling them.

Family VIPERIDAE; a single species, *Vipera russellii.*

Russell's viper, while not an aggressive snake, is dangerous and capable of inflicting a deadly bite.

Family CROTALIDAE is represented by the genera, *Trimeresurus* and *Agkistrodon.*

These snakes are equipped with poison and large fangs and at least some species are capable of injecting with a bite, a sufficient quantity of venom to produce death. While many bites from serpents of the genus *Trimeresurus* produce only dangerous wounds, they should be regarded as dangerous to man. *Agkistrodon* is regarded as being even more dangerous and it too has very large movable fangs.

Eyes: The serpents have lost movable eyelids, while the eye itself maintains ability of movement of a greater or lesser degree. The eye is covered by a watch-glass disc that is attached by tissue to adjoining scales, and its surface is shed with the surrounding surface when the skin is shed. Since the eye originally was developed to function under water, tears are produced behind the disc to create a surface of moisture so the eyes may function, the excess liquid being carried away through the naso-lachrymal ducts.

Occasionally this watch-glass scale is eliminated by complete fusion with surrounding scales as in the genus *Typhlogeophis*. Whether the Typhlopidae and Leptotyphlopidae have ever had a typical watch-glass eye-scale covering the eye may be doubted. Here the eye is below a flat ocular scale or may be partially covered by two scales, and the eye may be visible or invisible. Such a change from a typical watch-glass type of eye covering, to the encroachment of the supraocular or other scale to cover the eye, is certainly a generic character.

Ears: Most of the readily recognizable external parts of the ear are wanting in the snakes. There is no external cartilage, no external auditory tube, no typical tympanum or tympanic cavity, nor is there a visible Eustachian tube. The inner ear consists of a columella which is situated between the fenestra ovalis on the skull and the quadrate bone. The canals and the essential sensory cells of hearing are, as normally, in the skull. A sense of hearing in snakes is present without question. Whether it is hearing resulting from the vibrations that are transmitted by air waves to the inner apparatus through the columella or by the other types of vibration through the body and muscles due to contacts with the earth may be a matter of debate.

Tongue: The forked tongue of all snakes may be extended beyond the mouth and is a conspicuous appendage. Among the sea-snakes, however, there are two openings for its extrusion and normally with the mouth closed only the two branches of the tongue can be extruded. It is a generally accepted idea that the tongue, rather than an organ of taste, maybe an organ of smell, that functions in connection with Jacobson's organ. The color of the tongue varies from pink, flesh color and gray to black.

Vertebral column: The vertebral column of snakes consists of a large series of separate bones that are interlocked. The number varies remarkably. In most snakes there is a vertebra for each ventral scale and each subcaudal or one for each transverse scale-row in most snakes. The ventral-subcaudal total number is as small as 150 in certain *Calamaria* while the number in certain sea-serpents reaches 564. I have not ascertained whether the vertebra are actually as numerous. The family *Colubridae* may be separated into two groups on the basis of the presence of hypapophyses on the ventral part of vertebra—Hypophysa; on the absences of hypapophyses—Anhypophysia.

Hemipenes: The intromittent organs of each serpent are two, and these, when not exserted, lie in pockets at the base of the tail. During congress, for the most part a single one is used at a time. E. D. Cope made an elaborate study of these organs and used their characteristics as a basis for classification. This is rather an involved procedure unless they are extruded. Malcolm Smith in his Fauna of British India, Serpentes (1943) has examined the hemipenes of most of the species of Thai snakes and recorded his findings. I have not utilized this character, largely because of the difficulty first of making the dissection and interpreting the findings. Only on rarer occasions is it called upon to serve as the sole character for separation of species.

In many cases the organs are covered with longer or shorter spines which may serve to prevent disunion during congress.

Mate-finding and courtship: Various types of sense organs are called upon in mate-finding. Sometimes this depends upon organs of hearing, sometimes touch, sometimes sight, sometimes odor; while often more than a single sense may be involved. Since there is an obvious minimum of external sexual dimorphism in serpents one would suspect that the sense of sight is not the primary sense involved. The inability to produce sounds audible at a distance would seem to preclude hearing as a factor.

Practically all snakes have anal glands which exude substances which volatilize to produce odors and which by diffusion and air-movement are carried considerable distances; or if in water diffusion likewise takes place and all odors are mechanically moved by waves and currents.

One concludes that the serpent's sense of smell is of significant importance as a species finding (mate-finding) sense. However sex recognition, once the members of the species are together, may depend on other senses such as touch or contact sense. Since most species are marked and colored in a specific manner, sight may be able to verify species recognition, but one suspects that small external dimorphic character differences, such as the micro-tuberculation of head-scales, differences in ventrals and subcaudal counts; differences in tail length and contour, or small color differences (*i. e.*, presence or absence of a white ventro-lateral line in male *Trimeresurus*) would not be likely to be a significant help in determining the sex.

As stated, many serpents have characteristic odors and at least in certain species might be identified by odor alone by man, as well as by their own kind.

Adaptation: In the evolution of the serpent following his presumed underground sojourn, various groups of individuals, in occupying new habitats which offered food and safety, became further specialized in their bodies, that is to say that the habitat tended to select the more favorable mutations (which are continually taking place in all animals). Thus we may suppose that those that sought food or safety in trees became specialized in climbing ability; and since elongate slender snakes, and snakes with compressed bodies and keeled ventrals seemingly climb better and move with greater ease and greater rapidity, they are more successful in food-finding. The compressed body gives greater strength in reaching out to a more distant branch. Thus mutations involving these characters were chiefly selected since all represent survival values.

Those that entered the sea for food became "specialized" perhaps in the swimming locomotion. The body in many forms became compressed, the tail actually compressed to form a thin paddle. Some of the poisonous sea-serpents actually specialized in obtaining food "underground" below marine waters, a source of food in the form of tiny serpentiform eels that themselves may have gone "underground" in search of food for which there was less competition. In this case seemingly only the serpent's head and the anterior part of the body became specialized. The head on certain such forms may be reduced to the size of a large barley grain. The neck and anterior body may have a diameter not or but little greater than the head. The posterior part may have a much greater diameter. This enables the snake to insert its head in an eel burrow, bite and poison the eel, and when dead withdraw the animal from its burrow and engulf it.

Transition from a marine habitat to a freshwater habitat may take place at the mouths of rivers extending into the sea. In a few cases typical marine forms have been taken in rivers unaffected by tidal water. Rising coasts often trap deep bays, first forming salt-lakes, but which, because of overflow, gradually lose the marine salts. This slow change permits a "period of grace" in which the animal may gradually adapt to the gradually changing environment. Occasionally volcanic flows rather than rising coasts separate bays from the sea, trapping at the same time their marine faunas. Thus in The Philippines, in Lake Taal, a lake perhaps so formed, the sea-serpent *Hydrophis semperi* is just such a trapped species.

Water consumption: Many snakes, such as pythons in the tropical fauna and crotalids in desert temperate regions, when in captivity

may consume very little water. The water requirements are often met by the liquids in the bodies of the animals consumed as food, and the water developed in the process of metabolism. Others in captivity may consume more. Serpents seemingly are adapted so that the water-loss from the body is not great. Some water, of course, is lost in the process of breathing. Many snakes lose no perceptible amount of water in the process of urination and the salts eliminated from the body through the kidneys is sent via the cloaca and emerges from the body as a mass of white crystals together with the feces. Some liquids may be evident in the feces but the quantity is small. One concludes that loss through the surface of the body is negligible.

Sea-serpents living as they usually do in a medium containing an excess of salts and consuming water and animal flesh likewise permeated with salts probably have some special mechanism for the elimination of excess salts reaching the body fluids, since other vertebrates, (frogs, mammals, birds and turtles) living in the sea or feeding on marine organisms have developed such organs.

Sexual dimorphism: This is not strongly marked externally, but small differences do occur. Thus probably the best external criterion for determining the sex of a snake is an examination of the base of the tail, especially if the animal is adult, since there the hemipenes cause a swelling that is absent in females. In certain species, at least during the breeding season the scutes of the top, sides and underside of the head of males may have very numerous fine spines, tubercles, or minute knobs. Some other species may develop these decorations on a number of scales in the region of the vent. When a female is gravid, the presence of eggs or embryos may be discovered by lateral pressure on the body. But in a series where both sexes are known to be present relative measurement of body and tail will give a clue to the sex. In most females the body is proportionally longer and the tail proportionally shorter than in adult males of the same length. Further evidence can be ascertained by a count of the ventrals and subcaudals. Females normally have more ventrals and fewer subcaudals than the males. Examination of the base of the tail will show that in the males at the point where body and tail are joined the diameter of the two are nearly the same in adults. In females the body diameter normally is greater at this point than in males. In some snakes the count of scalerows about the various parts of the body is greater in the

female than in the male. This has been observed in sea-serpents and to a much lesser extent in certain of the crotalids.

Differences in color or pattern between the sexes is not marked save in a few cases. In one Thai species of *Trimeresurus* a whitish or cream ventrolateral line is present in the male but is normally absent in the female.

The juvenile coloration is often more prounced than in the adult. Sometimes this juvenile type of coloration is retained with greater clarity in the male than in the female. In the Sauria this is usually the reverse, the female retaining the juvenile color and pattern longer than the male.

Classification and Evolution. The classification of serpents and their arrangement in an evolutionary series offers probably no greater problems than do other groups of the vertebrates. As has been suggested, we must regard the ancestors of snakes as quadrupedal animals, but the evolutionary happenings prior to the acquisition of the serpentine form has been largely lost in oblivion. We presume that the highly specialized serpent body had already been acquired before the present evolutionary trends began. That is, the immediate ancestor (or perhaps more than one) of the serpents was a very highly specialized creature and definitely not a generalized form. This is not surprising or unique since we may point to highly specialized animals as ancestors of Chiroptera or of the Aves, or in the reptilian group of the Testudines.

Since the serpent had lost its original parts or organs of locomotion, once it attempted to enter into competition with other than subterranean feeders its greatest need was the development of new parts or organs for locomotion of a different sort than it had been using; and since most food in the terrestrial world or superterrestrial world has many competitors and the food materials are in portions of varying sizes it became necessary for serpents to develop the means to acquire them. Thus we find that mutations developing along these lines were fixed by the environments, and organs came into being for overtaking, holding and swallowing these various types of food. One of our older concepts in zoology is that all adaptations may be retained for either of the two basic ends of existence—self and race preservation. Thus we might classify all the various acquisitions or adaptations in relation to these basic ends. Some adaptations might appear in both categories since locomotion involved in climbing might be just as important

in mate-finding as in food-getting. The development of special excretory substances in glands, for its injection by hypodermic fangs would appear primarily as devices for food-getting. The use as a defense is no doubt secondary. The partial suppression of certain sense organs (hearing) and the development of others such as the facial-pit organ of the Crotalids, labial-pit organs of the pythons may be regarded in connection with the obtaining of food, while the elaboration of nuchal glands, and anal glands are likely to serve primarily in mate-finding. Such adaptations as the development of a ligamentous attachments of the lower jaws to replace a solid bony attachment; the muscular development permitting constriction of prey; an egg-crushing mechanism resulting from the perforation of the esophageal walls by the anterior vertebrae; the development of elongated non-grooved holding teeth, of teeth curving backwards in both maxilla and mandible, or the production of a very high number of teeth small and of equal size (Sibynophinae), are all adaptations having to do with catching prey holding it, or consuming it.

When one further considers this field of adaptations one wonders why there have been no adaptations for the use of plant food, as have appeared in the Sauria and in certain other groups of reptiles. If such mutations have occurred we must presume that they proved lethal. Nor are many adaptations discernible for the use of invertebrates for food. Members of the Family Dipsadidae do make use of invertebrate molluscs, and young snakes and some adults of many groups consume invertebrates (worms and insects). A few species have developed appetites for eggs of both birds and reptiles while others have a liking for the eggs and larvae of amphibians.

CLASS REPTILIA

SUBCLASS SYNAPTOSAURIA

Living animals belonging to the class *Reptilia* include turtles, crocodiles, Tuatera, serpents and lizards, but it is different to give a diagnosis based exclusively on external features since these are so diverse.

Many of the groups of reptiles, Subclasses, Orders, and Suborders, are extinct. These include the great dinosaurs, the phytosaurs, plesiosaurs, and a number of others less well known; but no attempt will be made to consider these.

Representatives of all living groups, with the exception of the Tuatera (Rhynchocephalia), occur in Thailand. There is little dif-

ficulty in distinguishing between crocodiles and turtles or between these groups and the serpents. However young crocodiles may have a superficial resemblance to some of the larger lizards.

In this work we are concerned with a single Order, the *Squamata* which includes both the Suborders *Sauria,* the lizards, and *Sepentes,* the serpents or snakes.

It is not always possible to distinguish between all members of these two groups without a careful examination of some of the internal or concealed anatomy. The absence of the limbs is not an absolute criterion since some lizards may lack trace of external limbs, while some serpents may have vestiges of external limbs.

ORDER SQUAMATA

SUBORDER SERPENTES

This group is treated here under ten family groupings, which may be differentiated by the following key:

KEY TO THE FAMILIES OF SERPENTES

1. Small serpents lacking widened ventral and subcaudal scales; eyes under head-shields visible or invisible, body scales uniform; tail short, *Typhlopidae*
   Small to large snakes, the eye usually visible, but if under head-shields, the ventrals are widened 2
2. Vestiges of hind limbs lateral to the vent; relatively narrow ventrals not as wide as body 3
   No vestiges of hind limbs 4
3. Ventrals scarcely broader than adjacent body scales; usually not more than 23 scalerows about body ..... *Aniliidae*
   Ventrals much wider than adjoining scales; more than 40 scalesrows around the body ..... *Boidae*
4. No enlarged grooved poison-fangs in the front of the mouth 5
   Grooved or tubular poison-fangs in anterior part of mouth 7
5. Teeth present on the premaxillaries; enlarged head-shields behind parietals ..... *Xenopeltidae*
   No premaxillary teeth present, no greatly enlarged head shields behind parietals (except in *Dendraspis,* of the *Elapidae*) 6
6. A mental groove present ..... *Colubridae*
   No mental groove present ..... *Dipsadidae*
7. Maxillary bone longer, bearing teeth (with or without grooves) behind large anterior grooved fangs 8
   Maxillary shorter, usually bearing one or two large grooved or tubular fangs 9
8. Tail strongly compressed vertically; ventrals reduced or greatly reduced; maxillary with from two to 14 teeth following poison-fangs, *Hydrophiidae*
   Tail subcylindrical, not compressed; ventrals as wide or nearly as wide as body; none or one to five small teeth follow poison-fangs ..... *Elapidae*
9. Maxillary bone not hollowed out; no lateral facial sensory pit ..... *Viperidae*
   Maxillary bone hollowed and together with the prefrontal bone forms a deep pit on side of face ..... *Crotalidae*

FAMILY TYPHLOPIDAE Günther

Typhlopsidae Gray, Catalogue of the lizards in the collection of the British Museum, 1845, p. 130 (*part.*).

Typhlopidae Günther, The reptiles of British India, 1864, p. 170.

Body cylindrical, its diameter nearly equal throughout; body-scales nearly uniform; imbricate; head-scutes imbricate. Pelvis usually present as a single bone or cartilage, but no external evidence of a limb; eye, covered with scutes, usually visible. Maxillary arch incomplete; skull lacking pterygoid and supratemporal bones; maxillary bone transverse, loosely attached to skull, with teeth directed backwards; no teeth on mandible; quadrate directed forwards.

Of the recognized genera, *Typhlops* is the largest and of nearly world-wide distribution in tropical and subtropical regions. It is known in Mexico, Central and South America, southern Europe, Africa, Madagascar, south Asia, the Indo-Australian Archipelago to and including Australia.

Unfortunately this family has not been studied too well and it would seem that the large genus *Typhlops* is a composite of several genera. Thus, as an example—some forms have a single row of scales for one vertebrae, some have two, and some perhaps three. Certainly these would be considered as generic characters in the Colubridae. Perhaps the reason for this failure to examine carefully the anatomy of these serpents is due largely to their small size.

Genus *Typhlops* Oppel

Typhlopes (part.) Schneider, Historiae amphibiorum naturalis et literariae, fasc. 2, 1801, p. 339.

Typhlops Oppel, Die Ordnungen, Familien und Gattungen der Reptilien als Prodrom einer Naturgeschichte derselben, Munich, 1811, p. 54 (type of genus, *Anguis lumbricalis*).

Diagnosis: Small burrowing snakes; snout projecting beyond mouth; head not distinct from neck; eye covered with scales, often invisible; nasal scute partially or completely divided; mouth ventral, upper lip bordered by rostral and four supralabials; rostral bent back over snout, often reaching level of eyes; an ocular preceded or not by a preocular, with or without a subocular; a supraocular normally present; rostral followed by a single prefrontal, a frontal, and an interparietal; one or two pairs of parietals not strongly differentiated from body-scales.

The number of species in this genus is large, exceeding two hundred, with doubtless many undiscovered forms.

The number of species heretofore recognized in Thailand is five. Two recently described ones and one revived species are also included here. All of the species are small, some especially so. *Typhlops braminus* reaches a length of about 180 millimeters, while the largest Thai species, *Typhlops diardi,* may attain a length of 430 millimeters.

The small to diminutive serpents of this family have a world-wide distribution in warmer temperate and tropic zones. Most of them are burrowers and they are usually to be found after rains under stones, boards, etc., on the ground. In a few cases they have become arboreal, occupying a habitat in the roots of epiphitic orchids or ferns, especially the "birds-nest" ferns of the Indo-Australian Archipelago and the Philippines. Other species have become adapted to a sand habitat, and I have obtained certain new forms from sand among mangrove trees in Ceylon.

At the present time some two hundred species are recognized in the genus *Typhlops.* An examination or re-examination of the skeletal apparatus of many of these species may with profit warrant the resurrection of certain of the numerous generic names already proposed and now buried in synonymy. So far as is known all forms now recognized are typically oviparous. No aquatic forms have been described.

KEY TO THAI SPECIES OF TYPHLOPS

1. No preocular; ocular touching second and third supralabials; 22 scalerows at middle of body; eyes hidden; blackish above, each scale with a yellow spot leaving dark longitudinal lines on body; relatively large, to length 480 mm.; transverse scalerows about 470 ..... *lineatus*

   A preocular present touching second and third supralabials 2

2. A subocular present wedged between lower part of ocular and preocular; nasal completely divided; 18 scalerows about body; 520 transverse scalerows; length to 230 mm. ..... *floweri*

   No subocular present 3

3. 20 scales around middle of body 4

   More than 20 scales about middle of body 6

4. Nasal suture arises from preocular; head more or less dark; normally nasal completely divided 5

   Nasal suture arising from first or second labial; head, part of neck, and most of tail white; diameter of body in length, 40-60 times; transverse scalerows, 317; to 150 mm ..... *albiceps*

5. Head-scales smaller; one pair parietals; diameter of body in total length, 30-45 times; 290-310 transverse scalerows; length to 180 mm. . . *braminus*

   Head-scales larger; two pairs of parietals; diameter of body in total length, 28-43 times; transverse scalerows, 315-326; length to about 130 mm., *khoratensis*

6. A depression or pit under each upper head-scale; 24 scalerows; transverse scalerows 370; nasal incompletely divided; width in length about 30 times; no trace of eye visible; gray to ultramarine above, 13 ventral scale-

rows cream white; length 155 mm. ..... *trangensis*
No depressions or pits under upper head-scales 7

7. Black above, ivory-white below; scales in 28 (26) rows; transverse scalerows 384; length to 360 mm. ..... *muelleri*
Not black above 8

8. Brown to olive-brown above; gray-cream or brownish cream below; scales in 28 (26) rows; length to 430 mm. ..... *diardi*
Grayish olive or brownish above; yellowish on venter; 22 scalerows; 368 transverse scalerows ..... *siamensis*

Typhlops lineatus Boie

Typhlops lineatus Boie, Isis, 1827, p. 563 (type-locality, Java); Schlegel, Abbildungen neuer oder unvollständig bekannter Amphibien . . . 1844, p. 39, pl. 32, figs. 32-34;* Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 15 (Singapore, Penang, and Malacca, in Malaya; Java; East Indies); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 4 (Sumatra, Nias, Borneo, Java); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 102-103; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, p. 212; *ibid.* vol. 2, no. 2, Dec. 1916, p. 158 ("Bangnara, Patani" [= Narathiwat, Narathiwat]); Tweedie, The snakes of Malaya, 1954, p. 28 ("uncommon in Malaya").

Pilidion lineatum: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 897.

Typhlinalis lineatum: Gray, Catalogue of the specimens of lizards in the collection of the British Museum, 1845, p. 134.

Typhlina lineata: Günther, The reptiles of British India, 1864, p. 171, pl. 16, fig. B.

Diagnosis: Large species; snout rounded and strongly projecting; no preocular or subocular; ocular touching second and third labials; 22 scalerows around body; nasal not completely divided; eyes hidden; prefrontal, supraoculars, and frontal rather large, all transversely widened; blackish above, each scale with a yellow spot, or yellowish with dark brown longitudinal lines running between scalerows; head and venter yellowish white.

Description of species (from P. K. No. 110 near Bukit Besar, Na Pradoo, Pattani, southern Thailand): Snout rounded, strongly projecting, flattened on ventral surface. Rostral very broad, a little more than three fourths as wide as head; width of ventral portion of scale between nostrils nearly one half of greatest width of rostral; nasals large, not meeting behind rostral; nasal partially divided, suture running from first labial through nostril, and a very short distance beyond nostril; no preocular; an ocular scale behind nasal, but eye, completely invisible; four supralabials, three touch ocular, which is bordered posteriorly by two postoculars; prefrontal large, forming a straight transverse suture with rostral; frontal about half size of prefrontal; supraoculars transversely widened, nearly as large as prefrontal; parietals indistinctly differentiated.

* Günther, *loc cit.* p. 171, considers Schlegel's figures "incorrect."

Scalerows: anteriorly, 24, at middle, 22; scales in a row from tip of lower jaw to end of tail, 470 ±; nine subcaudals, tail ending in a rounded plate bearing a small spine; scales preceding vent not clearly differentiated from adjoining scales; scales largely transparent, bearing a symmetrical microscopical grill over under-surface except where attached to body.

Color: Above light yellowish-brown with a series of ten dark lines from neck to tip of tail, the two outer consisting of a row of small dots, some occasionally being absent; entire ventral and ventrolateral surface uniform cream-white. Head light brown with some black flecks.

Measurement in mm.: Total length 473 ±; tail length, 8; width of body, 10; width of head, 7.

Variation: The species usually is reported as having only 22 scale rows, but whether counts are made other than at the middle of the body I cannot say. The uncertainty, as regards an accurate scale count and measurement of the specimen here reported is due to the broken condition of the specimen.

Boulenger, describing the color of a specimen, says that it is blackish above, each scale with a yellowish spot, the spots tending to form light lines of yellowish or pale brownish with dark longitudinal lines running between the series of scales; head and lower parts yellowish white.

The species is known to reach a length of 480 mm.

Remarks: I believe the specimen reported here to be the second found in Thailand. One specimen was taken some 45 years ago in the present province of Narathiwat. Outside Thailand the species is known in Malaya, Java, Borneo, and Sumatra. According to Tweedie (*loc. cit.* 1954) it is everywhere uncommon.

This specimen was obtained by Nai Prayoon Kananuracks, who has permitted me to study it.

Typhlops floweri Boulenger *in* Flower

Typhlops floweri Boulenger, *in* Flower, Proc. Zool. Soc. London, 1899, p. 654, pl. 37, fig. 2 (type-locality, "Siam"); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, Mar. 1915, p. 212; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 21 (Bangkok); M. Smith, The fauna of British India including Ceylon and Burma . . ., Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, p. 46.

Diagnosis: A small snake with a projecting rounded snout; nostrils lateral; body, slender, elongate, diameter in length about 85 to 90 times; nasal completely divided; 18 longitudinal scalerows around body; rostral approximately three fifths width of head at

level of eyes; no tail spine; nasals not touching behind rostral; a subocular present. Black or black-brown, tip of snout yellowish.

Description of species (from type B. M. No. 98.11.8.26, renumbered 1946.1.10.55): Head somewhat flattened, distinctly wider than deep; snout strongly projecting beyond mouth; rostral approximately three fifths as wide as head at eye-level, but not reaching as far back as level of eyes; nasal completely divided; prefrontal larger than frontal, broadly in contact with rostral; frontal and interparietal not as wide as parietals; preocular rather small, its suture with ocular passes over back edge of eye; eye for most part under ocular; suture with supraocular passes above eye; subocular* wedged between lower part of ocular and preocular; two postoculars; suture from nostril reaches second labial; 18 scalerows about body. About 520 transverse scalerows.

Color: Black or very dark black-brown, extreme tip of snout yellow; rostral and nasal scales light brown with minute yellowish dots; a yellow spot at vent.

Measurements in mm.: Total length, 228;** tail, 6.5; width of head, 2.5; width of body, 2.5; width in length, approximately 90 times.

Recently, in the British Museum, I re-examined the type of *Typhlops floweri.* My measurements show that the width of the rostral is greater (practically three fifths of the width of the head rather than "two fifths" reported by Boulenger). The rostral fails to reach back to the level of the eye. The prefrontal is larger than the frontal and broadly in contact with the rostral. The frontal and interparietal are not as wide as the parietals. The preocular is relatively small.

The presence of a subocular is not mentioned in the type description; and the figure given by Flower (1899) omits the subocular scale.

There are two specimens of *Typhlops floweri* in the U. S. National Museum. No. 72709, collected by Hugh M. Smith at Bangkok is a mutiliated specimen with part of the posterior part of the body missing; the rostral shows scattered glands which appear as small lights dots. The preanal scales are moderately enlarged.

The second specimen, No. 76163 was taken from the stomach of *Xenopeltis unicolor* captured at Bangkok. This specimen agrees

* The figure given in Flower, *loc. cit.*, omits this scale.

** The original description gives the length as 210; the specimen is now somewhat elastic, hence the greater measurement.

with the type in lacking a pointed spine on the tip of the tail. Both of the above specimens agree with the type in having a subocular scale.

I have the posterior portion of a species of *Typhlops* taken from the stomach of a serpent (*Cylindrophis rufus*) at Bangkok. The remains of the specimen offers a puzzle in identification. The tail lacks the terminal spine, but the scalerows on the body number 24. The color is black on the dorsal 12 rows and creamy white on the ventral 12 rows. The fragment measures about 85 mm.; the diameter of the body, 4 mm.; there is a small triangular depression behind the vent; the tail measures 3.3 mm.

Miss Alice Grandison of the British Museum has been kind enough to verify the presence of the subocular in the type specimen.

The precise type-locality is unknown.

Typhlops albiceps Boulenger

(Fig. 1)

Typhlops albiceps Boulenger, Ann. Mag. Nat. Hist., ser. 7, vol. 1, Feb. 1898, p. 124 (type-locality, Chantabun [= Chanthaburi], SE Thailand); Flower, Proc. Zool. Soc. London, 1899, p. 654, pl. 37, fig. 1 ("Siam"); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 103 (Larut Hills, Perak, Malaya); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, Mar. 1915, p. 212 (Siam); The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 48-49 (Bangkok, Chanthaburi, San Kampeng Mts., in Thailand; Burma; Malaya).

?*Typhlops malaisei* Rendahl, K. Sven. Vet. Akad. Stockholm, vol. 29A, no. 10, 1937, p. 11 (type-locality, Dwana Hills, Burma).

Diagnosis: Snout rounded; nostrils lateral; no subocular, the ocular touching third and fourth labials; 20 scalerows around body; width of rostral one third to two fifths width of head; nasal suture arises from second labial. Head, neck, tail, and anal region white.

Description of species (from No. 1383, Na Pradoo, Pattani province): Snout projecting, rounded in lateral profile, truncate seen from above, and very indefinitely notched at rostral sutures; rostral narrowed anteriorly, widening above on snout to about two fifths of width of head; eyes not visible; nasal divided completely on left side (injured on right side); nasals not in contact behind rostral, separated by prefrontal; frontal slightly wider than prefrontal or interparietal; supraoculars smaller than parietals; preocular a little wider but nearly equal in height to ocular; one postocular; four supralabials, last largest, touching postocular; suture of nasal arises from second supralabial. No subocular.

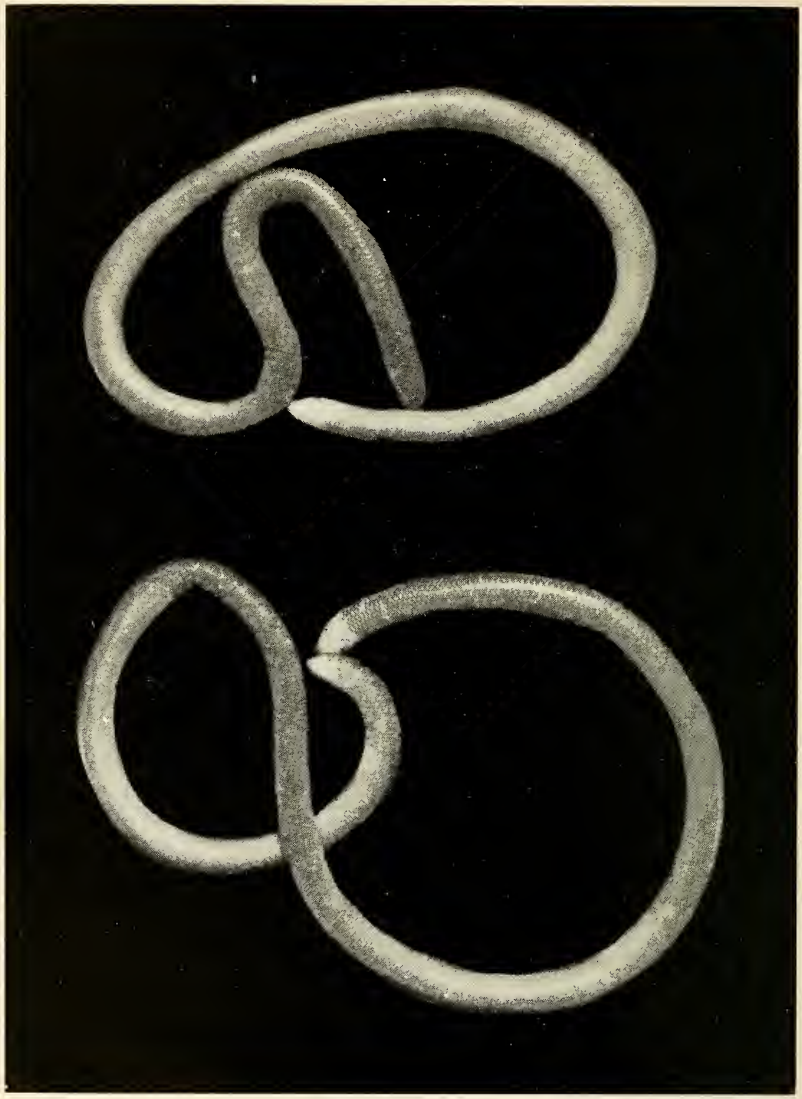

FIG. 1. *Typhlops albiceps* Boulenger. Upper figure, B. M. No. 1900.6.14.13. Actual total length, 164 mm. Lower figure, B. M. No. 1900.6.14.14. Actual total length, 183 mm. Both from Larut Hills (3500 ft.), Malaya.

Twenty longitudinal scalerows around body from head to tail. Diameter of body in total length (*circa*) 39 times; tail ending in a spinous point.

Color in life: Head and anterior part of neck white; tongue white; tail white above for almost its entire length; body normally brown

above but now grayish (probably nearly ready to shed skin); six to eight scalerows on ventral surface cream-white, adjoining one on each side partly brown, partly cream-white.

Measurements in mm.: Total length, 143 mm.; tail, 3; snout to vent, 140; width of head, 2.6; width of body, 3.7.

Variation: The suture of the nasal may arise from the first or second labial (*fide* M. Smith, 1943). The eye normally is dimly visible. The diameter of the body may be contained approximately 40 times in total length. Smith also refers to this species a specimen having a length of 255 mm., and a body diameter of 5 mm. This is from an unknown locality in Indo-China and the reference may be doubtful. Boulenger originally stated that 18 scalerows were present. Malcolm Smith has shown that 20 is the correct number in the type.

Distribution: This is a rare snake in Thailand. It has been taken in Bangkok, Chanthaburi, San Kampeng Mts., and Pattani. Elsewhere it has been reported in the Larut Hills of Perak, Malaya, and the Dwana Hills, Burma.

Remarks: M. Smith has perhaps correctly placed Rendahl's *Typhlops malaisei* in the synonymy of *albiceps,* but he has not seen the type.

I have examined the British Museum specimens, Nos. 1900.6.19.13 and 14, from the Larut Hills (3500 ft.), collected by A. L. Butler. These agree reasonably well with the type-description. The eye is dimly visible. There are 20 longitudinal scalerows in each. The transverse scalerows of the first are 317 of which 12 are caudals. The supraoculars and parietals are of about same size. The first of the two measures, 166 mm., the tail 4 mm., the second specimen measures 179 mm., the tail, 12 mm. (!) which is a remarkable length, and there are 25 transverse rows on tail. The nasal is not completely divided, the suture terminating at the second supralabial. A Bangkok specimen has a length of 194 mm., the tail; 2.5 mm. This specimen was collected by Stanley Flower (B. M. No. 98.11.8.25). In this the prefrontal is twice size of frontal. A slight depression, present behind the eyes, may be anomalous.

A specimen from Hong Kong has been referred to this species. It has a total length of 222 mm., a tail length of 3.2. There are 411 transverse scalerows, 12 of which are caudal. This variation of nearly 96 transverse rows suggest the wisdom of reconsidering the identity of this last specimen.

The type in the British Museum bears the numbers 97.10.8.17 and 1946.1.10.50. It measures 128 mm., the tail 2 mm.

Typhlops braminus (Daudin)

Eryx braminus Daudin, Histoire naturelle des reptiles, vol. 7, 1803, p. 279 (based on plate 43, Russell's Indian Serpents, vol. 1, p. 48; type-locality, Vizagapatam, India).

Typhlops braminus Cuvier, Règne animal, 2nd Ed., vol. 2, 1829, p. 73; Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 236; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, 1914, p. 8; *ibid.*, vol. 1, no. 3, 1915, p. 212; The fauna of British India, including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 46-48 fig. 14.

Unless one can examine the materials on which many of the references to *braminus* are based, it is impossible to present a correct synonymy. It is most probable that other species, because of small size and the concommitant difficulty of discerning and counting scales, have caused considerable confusion by being placed in the synonomy of *braminus*-species that should be regarded as distinct.

It is uncertain as to what part of the Oriental Region was the original home of this species. It has doubtless been carried by man through accidental means throughout much of the present wide range. One may postulate that it reached Acapulco, Mexico on Spanish galleons from the Philippines. I have traced the species 40 km. north of Acapulco, Mexico along the highway but it has been taken at least one other place in Mexico. If one were seeking a specific method for this transportation one might suspect potted plants and the suckers of bananas as the most probable means.

Diagnosis: Snout rounded, nostrils lateral; no subocular, the ocular touching third and fourth supralabials; a small species (170 mm.) with numerous glandules visible through the scutes of head; nasal divided, suture from nostril terminating at preocular; eye distinct, prefrontal touches rostral; 20 scalerows about body; diameter of body 30-45 times in total length; transverse scalerows 290-320 (*fide* M. Smith, 1943).

Description of species (from No. 34254, Muak Lek, Sara Buri province): Snout projecting beyond mouth, rounded in lateral profile, somewhat truncate seen from above; nostrils not visible from above; rostral narrowed on underside of snout, widening above so as to equal little more than one fourth width of head, reaching back to anterior level of eyes, forming a broad suture with prefrontal thus separating nasals; later scales completely divided, suture from nostril terminating at preocular; prefrontal and frontal

of equal size; interparietal likewise as large as two preceding scales, flanked laterally by two equal-sized parietals on each side; supraoculars somewhat diagonal, the suture with ocular crosses eye; four supralabials; preocular touches only third and fourth labials; scales in 20 rows, subequal in size; tail terminating in a spine on level with subcaudals; vent bordered anteriorly by five scales, two outer largest, median smallest; transverse scalerows to tail tip, 310.

Table of data on *Typhlops braminus*

LOCALITY	Bangkok	Bangkok	Chon Buri Bang Saen	Patthalung	Udon Thani
Number	33541	33546	34254	34697	34976
Total length	162	162	138	163	134
Width of body	4.9	4.85	4.5	3.8	3.65
Width in length	31	31	30	43	36.7
Transverse scalerows	327	332	312	310	312

Variation: Specimens taken at Hua Hin, Prachuap Khiri Khan were considerably darker in color, with slenderer bodies and somewhat less white coloration about the underside of the snout. The scales are smaller and there is seemingly a better defined separation of head and neck. A specimen showing this same variation was taken at Songkhla while two specimens from Phatthalung are similar to specimens in northern Thailand. The counts of transverse scalerows vary in Thai material from 300 to 332.

Distribution: I have taken specimens in the provinces of Udon Thani, Chon Buri, Sara Buri, Prachuap Khiri Khan, Phattahalung, Songkhla, and in Bangkok.

The species probably occurs in all of the Thai provinces. It is most likely to be confused in Thailand with the species herein described as *Typhlops khoratensis.*

Typhlops khoratensis Taylor

(Fig. 2)

Typhlops khoratensis Taylor, Univ. Kansas Sci. Bull., vol. 40, 1962, pp. 248-251, fig. 13a (type-locality, Muak Lek, Friendship Highway, Sara Buri province; Thailand).

Diagnosis: Body-width in total length approximately 28-43 times; rostral about one-third as wide as head at eye-level, failing to reach level of eyes; supralabials and infralabials relatively large; nasal

completely divided, the suture from preocular; two pairs of parietals differentiated; prefrontal, frontal and interparietal relatively large, subequal; 20 scalerows throughout body; transverse scalerows approximately 315 to 326.

Description of type: Rostral short, about one third as wide as head, failing to reach eye-level by a considerable distance; nasals completely divided, the suture arising from preocular; upper nasals not in contact behind rostral; prefrontal relatively large, as large as frontal or interparietal; supraocular only slightly smaller than frontal, its suture with ocular crosses eye; two pairs of parietals; preocular smaller than ocular, suture between them not crossing eye; eye only

FIG. 2. *Typhlops khoratensis* Taylor. No. M. 268, paratype. Chiang Mai, Chiang Mai, Thailand. Actual total length, 107 mm. (The dark mark is due to an injury.) From Taylor, Univ. Kansas Sci. Bull., vol. 43, 1962, p. 249, fig. 13a.

dimly visible; supralabials relatively large and distinct, especially fourth; a single postocular behind ocular between fourth labial and parietal; ocular and preocular relatively small, the preocular largest; infralabials relatively large.

Scales in 20 rows along entire body; transverse scalerows about 315.*

Color: Nearly uniform gray, the scales about mouth and underside of snout whitish.

Measurements and data of type and paratypes of *Typhlops koratensis.*

NUMBER	3183	267	268	612	W. 291	W. 292	33325
Length, snout to vent	125	103	105	104	119.7	118	100
Tail	3	2	2	2	2.3	3	2
Total length	128	105	107	106	122	121	102
Scalerows at:							
neck	20	20	20	20	20	20	20
middle of body	20	20	20	20	20	20	20
before tail	20	20	20	20	20	20	20
Transverse scalerows	315	320	326	319	321	319	331
Width of head	2.8	2.45	2.5	2.5	2.9	2.8	2.3
Width of rostral	0.75	0.7	0.7	0.7	0.7	0.7	0.6
Rostral reaches eye-level	no	no	no	no	no	no	no
Body-width	3	2.8	2.4	2.5	3.6	4	3
Width in length	41.5	37	43.7	40	33	28	33
Nasal divided	yes	yes	yes	yes	yes	yes	yes
Suture from preocular	yes	yes	yes	yes	yes	yes	yes
Parietals two pairs	yes	yes	yes	yes	yes	yes	yes

Remarks: This species occurs with and resembles *Typhlops braminus,* especially specimens when they develop a grayish to a silvery gray color before shedding. The character of the head-scales easily separates them and in the case of *T. braminus* the presence of distinct glands following along the head sutures is distinctive.

The two specimens from the Vienna Museum kindly loaned by Dr. J. Eiselt, without certain locality data, are probably from Laos or Thailand. The data were lost in movement of the collections during the war.

The species is named for the Khorat Plateau area of central (eastern) Thailand.

* The scales are counted in a row; occasionally there are intercalated scales or the row is incomplete hence the counts are close approximations.

Typhlops trangensis Taylor

(Fig. 3)

Typhlops trangensis Taylor, Univ. Kansas Sci. Bull., vol. 43, 1962, pp. 251-253, fig. 14 (type-locality, Khao Chong, Trang).

Diagnosis: A short (155 mm.), relatively thick-bodied species, width in length approximately 30 times; 370 transverse scalerows from rostral to tail spine. Vertebrae, 206; nasal incompletely divided, suture reaching to second labial; 24 longitudinal scalerows; rostral, nasals, oculars, preoculars, prefrontal, frontal, supraoculars, parietals, and perhaps also interparietal cover distinct pits or depressions visible through posterior part of each scale; no trace of eye visible; gray to ultramarine above (11 rows); 13 ventral rows cream-white, the dividing line rather sharply marked.

Description of Species: A short thick-bodied species; tail ending in a spine, and bending down at tip so that terminal spine is on a level with venter; snout rounded, seen from above, equally as wide as body; head width, 5 millimeters; greatest dorsal width of rostral 1.65 mm. about one third width of head; rostral forming a suture with prefrontal; a suture, partly dividing nasal, ends at second labial, scarcely passing beyond nostril above; prefrontal smaller than frontal; frontal about as large as supraoculars; interparietal a little larger than frontal and notched mesially on posterior border, a little wider than parietals but slightly shorter; preocular, about size of ocular, wedged between second and third supralabials; ocular, without trace of eye, wedged between third and fourth supralabials, and bordered posteriorly by two postoculars and partly by parietal; four supralabials; snout projecting 1.4 mm. beyond snout; scales in 24 rows, anterior median rows largest; vent bordered by five scales, two outer largest; 370 transverse scalerows counted along dorsal mid-line to spine on tail; (about eleven rows on tail); vertebrae, 206, terminal four or five very small; tail broader than long; a gland under ventral section of nasal; most dorsal head scales cover pits.

Color in life: Ultramarine on eleven dorsal scalerows; lower 13 scalerows cream-white; dorsal head-scales lighter than body, the pits showing a little darker; underside of head cream-white.

Measurements in mm.: Total length, 155; body-width, 5.1; tail-length, 2.8; tail-length in total length about 55 times; body-width in total length, about 30 times.

Remarks: The relationship of the species is not known; the larger size of the dorsal head scales and the pits appear to separate this

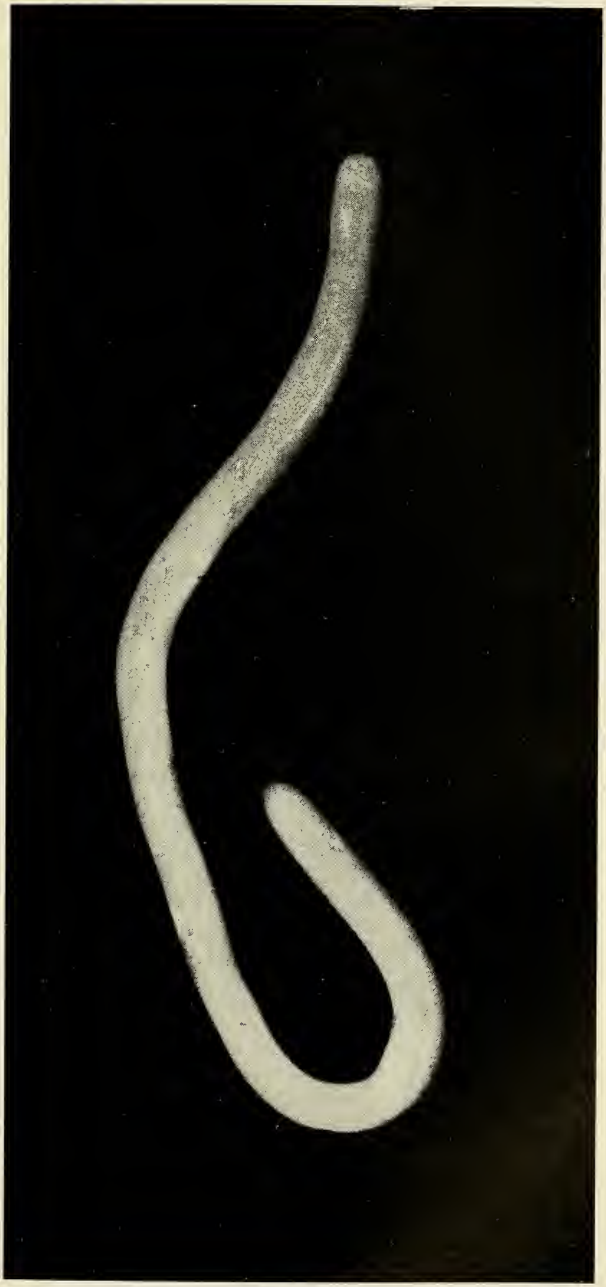

FIG. 3. *Typhlops trangensis* Taylor. Type. EHT-HMS No. 35754, from Khao Chong Forest Experiment Station, Trang province, Thailand. Actual total length, 155 mm. (From Taylor, Univ. Kansas Sci. Bull., vol. 43, 1962, p. 252, fig. 14.)

species very distinctly from other members of the genus occurring in Thailand. The pits are a significant feature and show with reasonable clarity in the photograph reproduced here.

The specimen was found under a rotting log about 30 meters from the shelter house at the first waterfall at the Khao Chong Forest Experiment Station, Trang province. The species is named for the province (Changwat) of Trang.

Typhlops diardi Schlegel

(Fig. 4)

Typhlops diardi Schlegel, Abbildungen neuer oder unvolständing bekannter Amphibiens 1839, p. 39 (type-locality said to be Cochin China); Duméril and Bibron, Erpétologie générale . . . vol. 6, 1844, p. 300 (state that type-locality is unknown); Malcolm Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 51-52, fig. 15 (*part.*); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1125-1126.

I cannot accept the synonymy proposed by Dr. Smith *loc. cit.* and do not reproduce it here. Moreover I am not wholly certain that the species here described actually is a member of the above species. Two other forms have been described from Thailand and it could well belong to one of them (see Remarks). It is a puzzle I cannot solve at the present time.

The treatment by various authors* of the snakes of the *diardi* "group" has varied greatly.

A brief history follows: The first two forms of the group were described by Schlegel in 1839, *Typhlops diardi* from? Cochin China, and *muelleri* from Sumatra. Duméril and Bibron in their Erpétologie générale (1844) recognized Schlegel's species and described a third, *nigroalbus*, from Sumatra. Gray (1845) described *horsfieldii* under the genus *Argyrophis*, from the Khasi Hills, Assam, and *bicolor* from Singapore. Peters (1861) described *striolatus* from Calcutta, India, and Jan (1864) described *schneideri* from Bangkok, Thailand.

Günther (1864) treating of the fauna of India, recognizes *striolatus*, *nigroalbus*, and *horsfieldii* and describes a new species *siamensis* from Thailand. Gray's *bicolor* is placed in the synonymy of *nigroalbus* and Schlegel's *diardi* the oldest name is made a synonym of *horsfieldii!* Stoliczka (1872) described *barmanus* from Moulmeim, Burma.

* Gray (1845), Cat. Liz. Brit. Mus., pp. 136-137; Peters (1861), Monatsb. Akad. Wiss. Berlin, p. 922; Jan in Jan and Sordelli (1864), Iconographie générale des ophidiens, livr. 9, pl. 1, fig. 3; Günther (1864), The fauna of British India, p. 175, pl. 15, fig. D; Stoliczka (1872), Proc. Asiat. Soc. Bengal, p. 144; Wall (1908), J. Bombay Nat. Hist. Soc., col. 18, p. 314; *idem, ibid.*, vol. 19, 1909, p. 609.

In the first volume of the Catalogue of snakes of the British Museum which appeared in 1893, Boulenger recognized *diardi* (considering *horsfieldii*, *barmanus*, and *striolatus* as synonyms), *siamensis*, *mülleri*, *schneideri*, and *nigroalbus* (with *bicolor* a synonym). Wall described *tephrosoma* in 1908, and *cinereus* in 1909.

Malcolm Smith in The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes (1943) has reduced this group of nominal forms to a single species, *diardi*, recognizing two subspecies, *diardi* and *muelleri*.

The material that I have been able to examine would appear to consist of more than a single species and shows certainly that a review of this whole group is most seriously needed.

If we accept this wholesale synonymizing, we have a burrowing snake with an amazingly wide range, extending as it does from Bengal, Sikkim and Assam, east through Burma, Thailand, and Indo-China, south through Malaya to Sumatra, Nias, and Borneo—this too a snake quite unlikely to be transported to far places by man.

As to the characters of this remarkable species, the following variation must be noted: Scalerows from 22 to 30; dorsal head scales small or dorsal head scales large; the rostral scale one half, one third (or less) two thirds (or more) of the width of the head; eyes visible or eyes invisible; coloration brown above and yellow below, black above and gray-white below, dark brown above, light brown below; head dark black or brown, the scales above showing some lighter markings; or head to behind eyes uniform yellow; the rostral reaching to or even behind eye-level or failing considerably to reach back to eye level, and finally and not least of variation, transverse scalerows varying between 260 and 414.

Surely to accept this as proper taxonomic treatment of these forms is to break down our concept of species in the family Typhlopidae, since as many as three of these forms may occur in a single area. This technique applied to other groups of *Typhlops* could reduce (just as erroneously) the total number of species very materially, thus benefiting those who would hold to the idea that the end of taxonomy is to provide labels (and as few as possible) for specimen jars on museum shelves, and that evolution is an interesting theory.

Diagnosis: Large, *Typhlops* reaching a length of over 400 mm.; snout rounded, projecting; tail ending in a pointed spine directed

downwards; a preocular present; no subocular; head not yellow; rostral reaching level of eyes, which are distinctly visible; longitudinal scalerows, 26, (24)*; transverse scalerows 324.

Description of species (from KUMNH No. 31436, "Korat" Thailand): Head relatively narrow; width of rostral (greatest) 3 mm.; greatest width of head, 7.2; rostral not reaching level of eyes by about .7 mm.; nasal partially divided with the suture arising from second labial, passing through nostril and traversing half distance between nostril and rostral scale; nasals touch at posterior edge of rostral; prefrontal enlarged broadly in contact with frontal which is a little wider but scarcely as long; interparietal in contact with frontal, but a little shorter; supraoculars diagonal, enlarged, separated mesially, not touching eye; parietals larger, at least transversely greater than supraocular; a large preocular, distinctly smaller than ocular, its posterior border notched, not crossing eye; narrower and less high than ocular; eye distinct; two small postoculars between parietal and fourth labial; four supralabials. Tail with a terminal spine directed downward. Scale-formula: 26, 26, 22. The scales shiny smooth, but showing under the free edges a minute "crisscrossing" grillwork; scales from rostral to above vent 305; vent to spine 8; or a total of 313.

Color: On neck and anterior part of body nine dorsal scalerows dark brown the upper edges of adjoining rows showing some pigment. This increases and much before middle of body is reached there are eleven dark-brown rows; anteriorly there are 17 and posteriorly 15 ventral rows without dark pigment, having a brownish cream color, with a suggestion of a salmon tinge; a dark indefinite mark with two arms projecting forward on rostral; other head scales show dark and light marbling, the dark predominating; the scales show lighter marks, not on scale-edges but actually below the scale forming a very narrow reticulum; anteriorly there is a distinct single straight transverse lighter line visible.

Measurments in mm.: Total length, 332; tail, 4.5; width of head 7.2; length of head, 11; width of body at middle, 11 mm.

Remarks: There have been two Thai species described; one from Bangkok, *Typhlops schneideri* by Jan and *T. siamensis* described by Günther from "Siam." This latter species is characterized by 22 scalerows and 368 transverse scale series. The upper and lateral parts are described as "uniform greyish olive, the lower yellowish."

* Duméril and Bibron, who studied the type, record 36 scalerows for the type (doubtless a misprint, intended for 26) and give for the number of transverse rows—324 for body, 8 for the tail, total, 332.

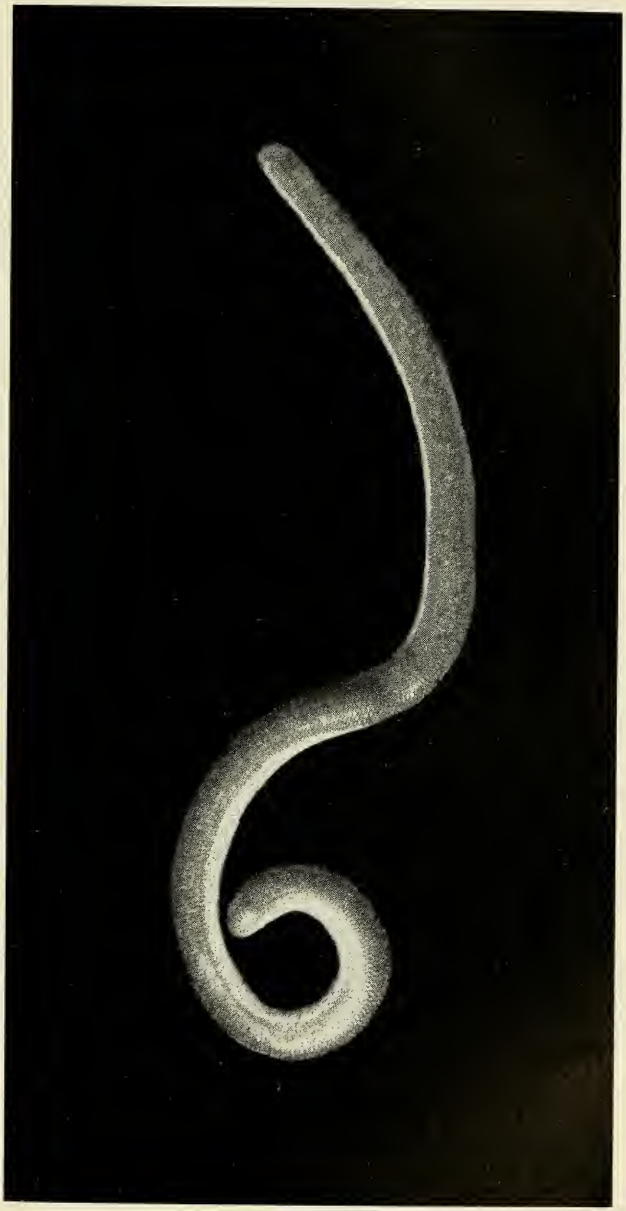

FIG. 4. *Typhlops diardi* Schlegel. EHT-HMS No. M177, from near Kuala Lumpur, Malaya. Actual total length, 300 mm.

This I believe certainly represents a distinct species. Boulenger, who may have seen the type of *schneideri*, reports 26 scalerows around middle of body; eyes hidden; total length 230 mm.

I have at hand also two forms from Malaya whose identities are in doubt. One has a white head, the rostral more than half width of the head but failing to reach level of eyes by 0.8 millimeter; eyes moderately distinct; the parietals much smaller than the supraoculars. Scales in 28 rows with 398 transverse scalerows. The "grillwork" seemingly is not present on the scales; four postoculars.

Still another specimen has the head dark, the nasals narrowly separated behind rostral which is one third of the head-width, and reaching eye-level. The preocular is wider than the ocular, its border crossing the eye; two postoculars; supraoculars in contact minutely. The parietals are wider than the supraoculars. The prefrontal, frontal and interparietal are large; and there are 362 transverse scalerows. The "grillwork" on the scales is not evident.

Typhlops muelleri Schlegel

(Fig. 5)

Typhlops mülleri Schlegel, Abbildungen . . . amphibien, 1839, p. 39, pl. 32, figs. 25-28. (type-locality Padang, Sumatra); Duméril and Bibron,* Erpétologie générale . . . vol. 6, 1844, pp. 298-300; Jan and Sordelli, Iconographie génerale des ophidiens, livr. 4, p. 19, pl. 6, fig. 2, Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 238; Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 25 (*part.*).

Typhlops diardi mülleri: (*part.*) M .Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 51-52, fig.

Diagnosis: Large typhlops, black above, yellowish-white below; nasal scale not completely divided, the suture arising from second labial; rostral reaches back to eye-level; subcaudal scales 8-13; scale-formula: 26 (28), 26 (28), 22 (24) a preocular; no subocular; eyes distinct; tail ending in a spine.

Description of species (from No. 34558 Bhetong, Yala province, Thailand): Head somewhat flattened, rounded in profile and when seen from above projecting about three millimeters beyond mouth. Rostral widening on dorsal surface of head to 44 per cent of head-width between eyes, reaching level of line drawn between front edge of eyes; prefrontal reaching frontal at a point; nasals meeting at a point behind rostral, not completely divided, but nearly so; suture from nostril running to second labial; pit below

* In a footnote Duméril and Bibron state: "M. Schlegel donne le nombre 22 pour les rangées longitudinales d'écailles et celui de 428 pour les rangées, transversales, nous, nous avons trouvé qu'il y a 28 des unes, et 402 des autres." Unfortunately in their own text in one place 23 is given as the number of scalerows, in still another place 28.

FIG. 5. *Typhlops muelleri* Schlegel. No. 34558, Bhetong, Yala, extreme southern Thailand. Actual total length, 355 mm.

nostril covered by nasal and scarcely visible externally; preocular reaching above eye and partly covering it, its back edge with a concavity at eye-level, its lower point between second and third labials; supraocular distinctly larger than frontal or parietal; ocular large, its lower edge between third and fourth supralabials; nostrils not visible directly from above.

Scales in 28 rows throughout most of body, reducing to 26 and 24 posteriorly near vent; scales smooth; 384 transverse scalerows from mental to tip of tail.

Color in life: Blackish above, nearly uniform, but each scale darker near its center, covering nine scalerows anteriorly, eleven posteriorly; pigment tending to cover outer rows; thus at mid-body 13 rows with pigment, outer row not uniformly covered; 15 rows low on sides and on venter cream-white; ventral and front part of head similarly colored; narrow light line borders rostral; subcaudals blackish with two whitish areas; terminal point of tail white.

Measurements in mm.: Greatest width of head, 8; width at eyes, 7; length of tail (vent to tip), 4; total length, 355; width of body at middle, 11; one centimeter in front of vent, 12.

Distribution: Specimens have been taken in Thailand only at Bhetong, Yala. Outside of Thailand the species is known certainly in Malaya, Singapore, and Sumatra.

Remarks: The type-specimen (data from Schlegel, and Duméril and Bibron) has 28 longitudinal scalerows, and 402 transverse rows.

This specimen likewise has 28 longitudinal scalerows but only 384 transverse rows. The specimens otherwise agree very well as to color.

Duméril and Bibron write: "Le Typhlops de Müller et le Typhlops noir-blanc [*Typhlops nigroalbus* described in the same work pp. 395-498] sont tellement voisin, l'un de l'autre que se n'est qu'apres un examen comparatif les minutieux que nous sommes arrivés à reconnoitre qu'ils appartiennent réellement à deux espèces distinctes." The longitudinal scalerows are 26 or 28; Transverse rows on body and tail approximately 326 + (8-12) a total of about 338. This species also is from Sumatra.

Typhlops siamensis Günther

Typhlops siamensis Günther, The fauna of British India, 1864, p. 175, pl. XVI, fig. D. (type-locality "Siam"); Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 24.

Typhlops diardi: M. Smith, The fauna of British India . . . Reptilia and and Amphibia, vol. 3, Serpentes, 1943, pp. 51-52, fig. (*part.*).

Diagnosis: Diameter of body in total length 33 times, 22 scalerows about body, nasal semidivided, suture from second supralabial.

Description of species (after Günther and Boulenger): Snout rounded and moderately projecting; eyes visible; nostrils lateral;

width of upper part of rostral less than one third of that of the head extending to level of eyes; the lower portion longer than broad; nasal not completely divided, suture from second labial; nasals not united behind rostral; preocular as large as ocular which extends nearly as far backwards as last labial; shields on crown of head subequal in size. The circumference at middle contained 13½ times in total length; length of tail less than width of head, the tail ending in a spine. Body with 22 scalerows; 368 transverse scalerows; diameter of body in total length, 33 times; grayish olive or brownish above; below yellowish.

Measurements in mm.: Total length, 166.

Remarks: The type specimen was collected by Mouhot in Siam, the exact locality unknown.

Family Aniliidae M. Smith

Aniliidae M. Smith, The fauna of British India . . . vol. 3 Serpentes, 1943, p. 94.
Ilysiidae Boulenger, The fauna of British India . . . 1890, p. 249.

Diagnosis: Body generally cylindrical with uniform scales, ventrals not or but feebly enlarged. Bones of skull closely united. Dentary, articulare, coronoid, and splenial firmly united; quadrate vertical in position; parietals greatly elongated; premaxillary with or without teeth, touching nasal bone; prefrontal bones border nasals; hypapohpyses absent; vestiges of pelvis and legs present, latter terminating in a clawlike appendage lateral to vent.

Two genera occur in southeastern Asia, the Malay Peninsula, and the East Indies. One genus, *Cylindrophis,* is known to occur in Thailand. The other genus, *Anomalochilis,* has been found in Pahang in Malaya (two specimens of *A. leonardi*) and in Sumatra (two specimens of *A. weberi*). This genus may be looked for in southern Thailand. It may be recognized by the absence of the mental groove and the presence of leg remants. A third genus is known from northern South America.

Genus *Cylindrophis* Wagler

Cylindrophis Wagler, Icon. Amphib., 1828, p. 5; Natürliches System der Amphibien, 1830, p. 195 (type *C. resplendens*).

Diagnosis: Body cylindrical, of nearly equal diameter throughout; scales smooth, ventrals feeble enlarged, body scales small, imbricating, subequal; nasals in contact behind rostral; no loreal present; preocular absent. Nine to twelve teeth on maxilla; premaxilla without teeth.

Only a single species of *Cylindrophis* occurs in Thailand.

Cylindrophis rufus (Schlegel)

Tortrix rufa Schlegel, Abbildungen . . . Amphibien, 1844, p. 111, pl. 33, figs. 11-13 (type-locality, Java).

Two subspecies are recognized, *C. rufus rufus* and *C. rufus burmanus*. The first occurs in Thailand. They may be differentiated by number of scalerows, the first having 21 the latter 19. It is not unlikely that *burmanus* occurs also in Thailand. It should be looked for in the low mountains and lowlands along the western, Burmese border.

*Cylindrophis rufus rufus** Schlegel

(Figs. 6, 7)

Tortrix rufa Schlegel, Abbildungen . . . —Amphibien, 1844, p. 111, colored plate 33, figs. 11-17 (type-locality, Java).

Cylindrophis rufa: Gray, Zoological miscellany, 1842, p. 47.

Cylindrophis rufus: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 900; Günther, Reptiles of British India, 1864, p. 179; Boulenger, The fauna of British India, Ceylon and Burma, Reptilia and Batrachia, 1890, p. 250, fig.; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 135; Flower, Proc. Zool. Soc. London, 1899, p. 656, pl. 37, fig. 3; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, p. 212; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 254; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 36-37; K. Schmidt, Copeia, 1928, p. 80; Bourret, Les serpents de l'Indo-chine, 1936, p. 24; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 96-98, fig. 28 (skull); Tweedie, The snakes of Malaya, 1954, pp. 28-29.

Diagnosis: A medium-sized snake, reaching a length of 865 mm.; scales in 21 rows, strongly iridescent; nasals in contact behind rostral; prefrontals larger than frontals; young with rings of white often interrupted on middorsal and mid-ventral lines, the dorsal marks disappearing largely or completely in old specimens; ventrals narrow.

Description of subspecies (from No. 36319, Bangkok, Thailand): Rostral higher than wide, pushing between nasals for half of their length; nasals rather small, forming a common suture behind rostral, nostril pierced in lower anterior part; prefrontals large, considerably broader than long, their common suture equal to about two thirds of their length, entering orbit broadly; frontal small, somewhat longer than wide, widest point on scute at anterior level of eyes; supraoculars reach very close to anterior level of eyes; no loreal or preocular; a small postocular; temporals, 1 + 2 + 3; scale following parietals and temporals relatively large; six supralabials

* *Anguis ruffa* Laurenti, Synopsis Reptilium, 1768, p. 71, type-locality "Surinam," is sometimes regarded a synonym of the species here considered. As this matter cannot be settled the next, certainly authentic name has been closen.

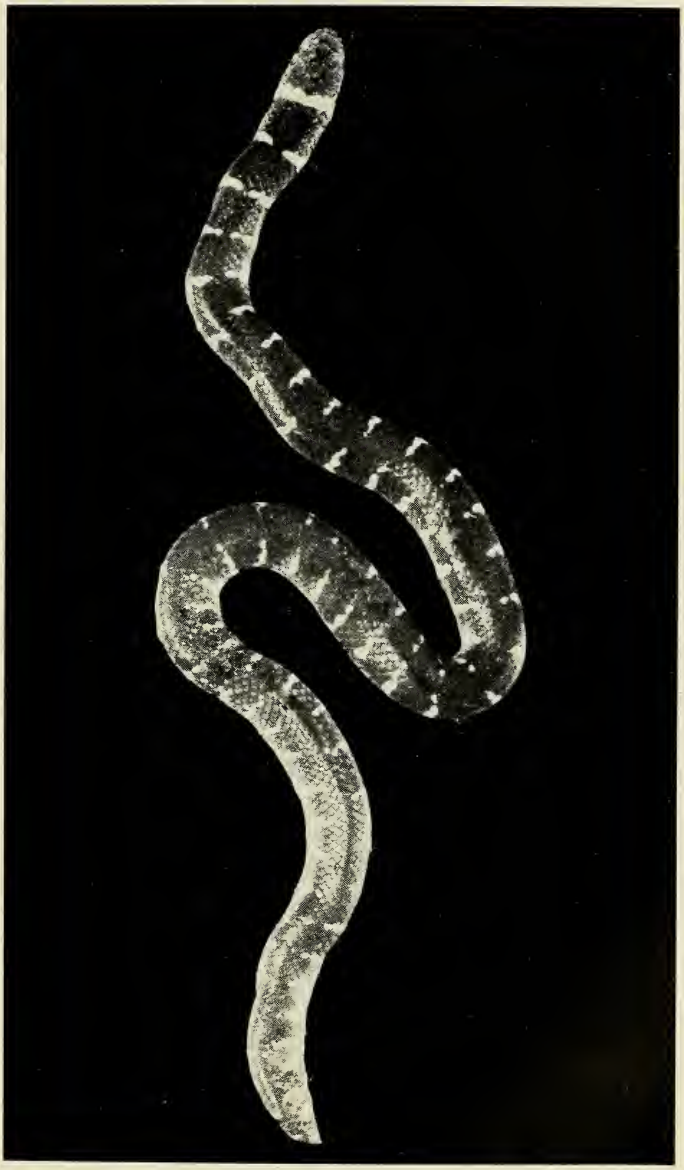

FIG. 6. *Cylindrophis rufus rufus* Schlegel. Young. No. 1656, Hotel Metropole grounds, Bangkok. Actual total length, 224 mm.; tail, 6 mm. (Collected by Vice Air Marshal, Nai Manob.)

third and fourth border orbit; six infralabials, first pair in contact behind small mental, first three border first pair of chinshields, which are a half larger than second pair; mental groove present. Scale-formula: 21, 21, 19, scales smooth without pits. Ventrals, 196 (to second pair of chinshields); subcaudals six, undivided; anal divided; eye small, its diameter less than its distance to lip.

Color in life: Above deep lavender-purple, skin between scales whitish; venter with approximately 48 gray-white bars extending slightly on sides, sometimes continuous across mid-line often broken on mid-line and alternating; underside of tail red with considerable darker pigment, except tip which is deep black.

Measurements in mm.: Total length, 793; tail, 18; width of head, 28; length of head, 35.

Variation: Variation recorded in literature for the present subspecies is as follows: The ventrals vary between 186 and 216, the subcaudals, from 5 to 7. There are 21 scalerows around the body except near the vent where the number is reduced to 17.

Young specimens have the whitish bars on the sides, (rarely meeting on middorsal line) clearly defined. As the snake grows older, pigment from the edges of the white scales begins to close in so that the light marks are rendered much darker, and finally the white is lost completely in old specimens.

Distribution: I have found several specimens on the grounds of Chulalongkorn University, and one specimen near Sara Buri in the province of the same name.

Outside of Thailand the species occurs in southern Indo-China, the Malay Peninsula and certain islands in the Indo-Australian Archipelago.

Remarks: Most of the specimens I have had available in this study are from Bangkok and environs. It must be regarded a common species of snake along the city waterways (klongs) and in gardens. It is subterranean in habit for the most part and is to be discovered ensconsed under boards, rocks, and other debris in the neighborhood of soft moist earth. It eats a variety of foods and is fond of other snakes.

FAMILY XENOPELTIDAE Cope

Xenopeltidae Cope, Proc. Acad. Nat. Sci. Philadelphia, 1864, p. 230.

Diagnosis: Body cylindrical. Scales smooth, imbricating; ventrals widened. Bones of skull well united; premaxillary bone touching maxillary, bearing well-developed teeth in line with maxillary

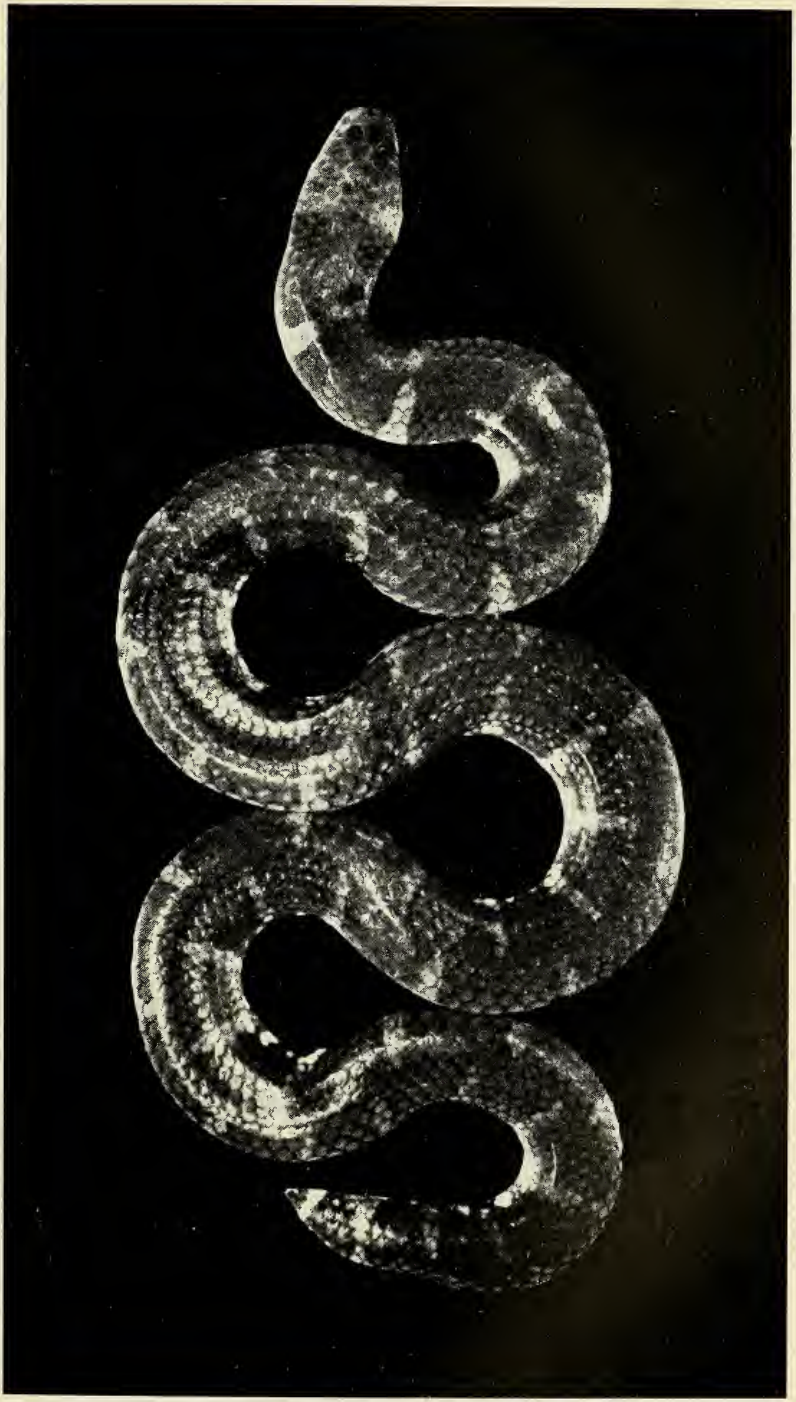

FIG. 7. *Cylindrophis rufus rufus* Schlegel. Adult. No. 33225, Campus Chulalongkorn University, Bangkok. Actual total length, 428 mm.; tail, 8 mm.

teeth; ectopterygoid loosely attached to maxilla; prefrontal sutured to nasal; dentary very loosely attached anteriorly to anterior end of articulare but free behind and movable; no coronoid; no postfrontal; a supratemporal supporting a short quadrate. Hypapophyses absent in posterior part of vertebral column.

A single genus, *Xenopeltis*, is known. There is a superficial resemblance between *Xenopeltis* and *Cylindrophis*, as for example, the rather stiff body; the union of skull bones; the presence of premaxillary teeth (in at least one form); the burrowing habit, and the shiny, strongly iridescent scales. The ear bones of the Xenopeltidae and Aniliidae too are similar, differing from those in other families of serpents. However the differences between the two families are equally as striking as similarities. One suspects that convergence, because of the burrowing habit, accounts for these similarities.

Genus *Xenopeltis* Reinwardt *in* Boie

Xenopeltis Reinwardt, *in* Boie, Isis, 1827, p. 564, (type of genus *X. unicolor*).

Diagnosis: Body cylindrical, head scarcely distinct from neck; eye small, pupil vertically elliptic; nasal divided; a large scale in front of eye that may be interpreted as a preocular, or a loreal, or a fusion of the two; scales smooth, in 15 rows throughout body; ventrals widened; subcaudals, except terminal, paired. Teeth numerous, 35-45 on maxilla, four or five on lateral areas of premaxillary; a group of enlarged scales lie behind parietals in occipital region.

Xenopeltis unicolor Reinwardt *in* Boie

(Fig. 8)

Xenopeltis unicolor Reinwardt *in* Boie, Isis, 1827, p. 564, (type-locality, Java); Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 904; Günther, The reptiles of British India, 1864, pp. 180-181; Theobald, Journ. Linn. Soc., Zoology, vol. 10, no. 41, 1868, p. 37; Journ. Asiat. Soc., extra number, 1868, p. 64; Boulenger, The fauna of British India, Ceylon and Burma, Reptilia and Batrachia, 1890, p. 276, fig. 85; Catalogue of the snakes in the British Museum, vol. 1, 1893, pp. 168-169, fig. 10; Flower, Proc. Zool. Soc. London, 1896, p. 878; *ibid.*, 1899, p. 657; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 113, figs. 35, 36; Wall, Journ. Bombay Nat. Hist. Soc., vol. 19, 1909, p. 292, pl. 10; *ibid.*, vol. 29, 1923, p. 361; *ibid.*, vol. 30, 1925, p. 806; Thompson, Proc. Zool. Soc. London, 1913, p. 415; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, 1914, p. 12; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 39-41, figs. 20, 21; Pope, Reptiles of China, 1935, pp. 77-78, pl. 5, H, I, and J; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, pp. 299-300; Bourret, Les serpents de l'Indo-Chine, 1936, pp. 27-29, fig. 12; Mahendra, Current Sci. Bangalore, vol. 6, 1938, p. 559, fig.; M. Smith, The Fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 101-102, fig. 31.

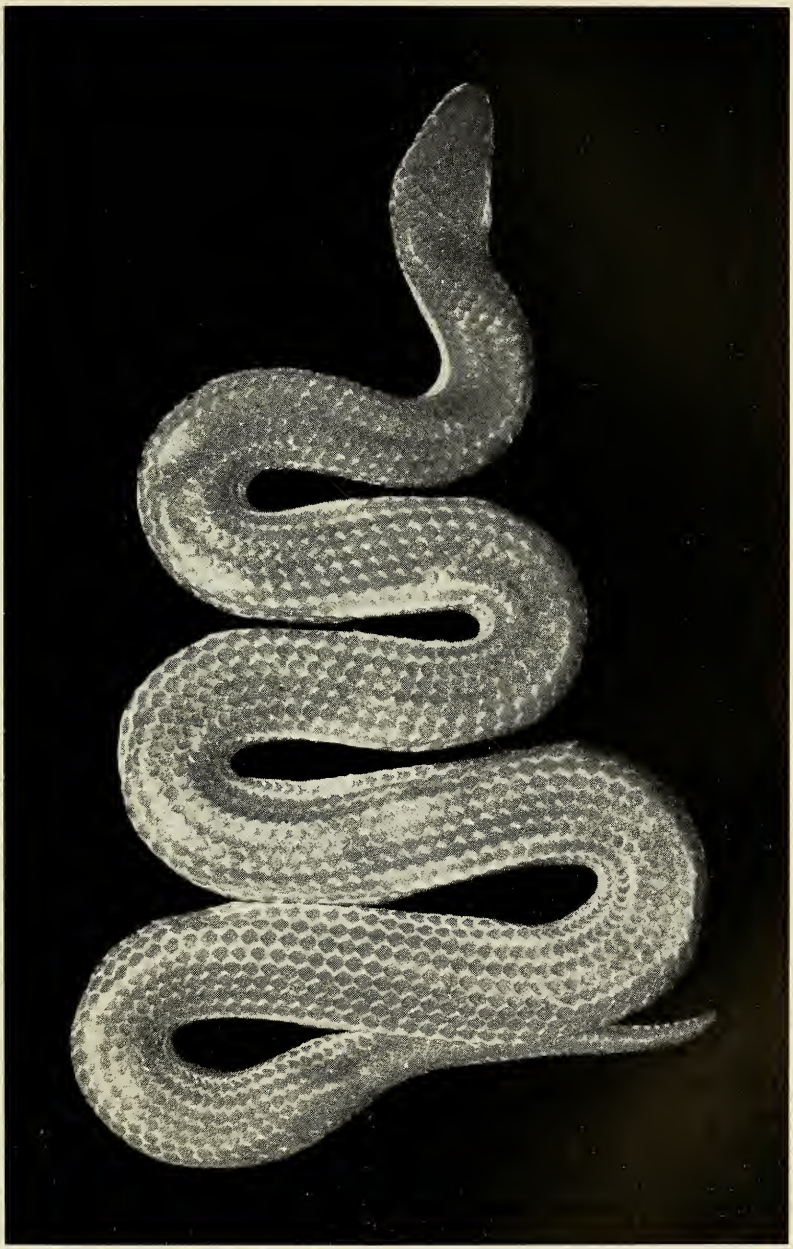

FIG. 8. *Xenopeltis unicolor* Reinwardt *in* Boie. No. 34235, Bang Saen, Chon Buri, southeastern Thailand. Actual total length, 597 mm.; tail, 63 mm.

Xenopeltis concolor Reinwardt *in* Boie, Isis, 1827, p. 564, (type-locality, Java).
Xenopeltis leucocephala Reinwardt *in* Boie, Isis, 1827, p. 564, (type-locality, Java).
Tortrix xenopeltis: Schlegel, Essai sur la physionomie des serpents, 1837, vol. 2, p. 20, pl. 1, figs. 8-10; and Abbildungen neuer oder unvolständig bekannter Amphibien, 1844, pl. 35, (substitute name).

Diagnosis: Characters of family and genus (see preceding).

Description of species (from No. 664, Hua Hin, Prachuap Khiri Khan): Body generally cylindrical; head much flattened, somewhat wedge-shaped; rostral a little wider than high, visible above as a triangular area; internasals small, deceptively appearing to border nostril which lies between the two nasals; prefrontals large, one on right side smaller than that on left, its posterior end narrowed to less than half width of the other scale; frontal longer than wide, shorter than its distance from tip of snout, about as long as parietals which are widely separated posteriorly by a large azygous occipital scale that is only a little smaller than frontal and in contact with it; a pair of enlarged scutes border occipital laterally; single scale immediately following occipital much larger than body scales; nasal divided, posterior part the longer; a large scale between posterior nasal and eye may be interpreted as a large loreal, as a preocular, or as a fusion of two scales; it borders the orbit, touching frontal and supraorbital; two postoculars, upper larger than supraocular; temporals, 2 + 3; supralabials, eight, anterior nasal wedged between first two, fourth and fifth border orbit; eight infralabials, first three touching first pair of chinshields which are smaller than first labials; no second pair of chinshields.

Scales smooth in 15 rows throughout body, seven dorsal rows subequal, outer rows growing larger, that bordering ventrals slightly the largest. Ventrals, 177; anals, 2; subcaudals, 32, first and last undivided.

Color in life: Head, uniform purple above, lips light with some brownish clouding; body generally purplish, edges of scales somewhat lighter; this lighter color becoming more obvious low on sides, where scale-edges are whitish cream on three lateral rows, leaving rows of purplish-lavender spots; outermost scalerow on each side with a transverse dash of lavender color; chin, throat, and venter generally cream-white; ventrals on posterior part of body with a few small, rather indistinct lavender marks, each subcaudal scale being half lavender, half cream.

Measurements in mm. (ANSP Nos. 19886 and 664): Total length, 964, 690; tail, 84, 70; width of head, 25, 19; length of head, 38, 28.2.

Variation: The ventrals vary from 173 to 196; the subcaudals from 24 to 31.

Distribution: In Thailand the species is widespread. I have taken specimens in Chiang Mai, Sara Buri, Chon Buri, and Prachuap Khiri Khan provinces, and also in Bangkok.

Outside of Thailand the species is known in Burma, Kwangtung province in China, Indo-China, Malaya, and the Indo-Australian Archipelago as far as Palawan in The Philippines, and Celebes.

Remarks: The specimen described was taken from under a small pile of dried grass on the golfcourse at Hua Hin, Prachuap Khiri Khan. An examination of its stomach contents showed that it had recently eaten. I identified a *Riopa bowringi*, a *Lygosoma quadrupes*, two *Ophioscincus anguinoides*, and a very young *Oligodon taeniatus*, all of which species were taken by me in the same general area.

Specimens taken elsewhere have been found usually under logs or debris, and usually just under the surface of the loose earth.

The largest specimen I have studied measured 964 millimeters in length. Asymmetry in the prefrontals is not uncommon. M. Smith (1943, fig. 31) depicts this condition.

The Thai name, in reference to its strong iridescence, is "sunray-snake." The serpent is a gentle creature seemingly unwilling to use its bite for defense.

FAMILY BOIDAE GRAY

This family, having world-wide distribution in the tropics, is represented in southeastern Asia by three species all belonging to the genus *Python*. The family comprises the largest of the living snakes; but there is perhaps some uncertainty as to whether the Asiatic pythons exceed the South American anacondas in length and weight.

A specimen of *Python reticulatus* has been recorded by Wall as reaching a length of 28 feet, with a weight of 250 lbs.; and a specimen of *Python molurus* 19 feet long that weighed 200 lbs.

The pythons are oviparous and the female *P. reticulatus* is known to brood her eggs by coiling about them. That this is possible without injury to the eggs is remarkable. *Molurus* has been known to lay 107 eggs at a single laying. The family has been divided into two subfamilies that are separated on the characters of the presence or absence of teeth on the premaxillary, and on the presence or absence of a supraorbital bone. The *Pythoninae* have the supraorbital bone and have premaxillary teeth. M. Smith

(1943) has not recognized the two subfamilies. The two subfamilies that have been generally recognized are: *Boinae* Gray and *Pythoninae* Boulenger. These may be differentiated by the following key:

KEY TO THE SUBFAMILIES OF THE BOIDAE

A supraorbital bone present; premaxillary bone toothed; subcaudals usually paired, oviparous ..... *Pythoninae*

No supraorbital bone; no premaxillary teeth; subcaudal series usually single, ovoviviparous ..... *Boinae*

Only the Pythoninae occur in Thailand and only a single genus, *Python*, is represented.

Subfamily PYTHONINAE Boulenger

Genus *Python* Daudin

Python Daudin, Histoire naturelle, générale et particulière des reptiles, vol. 5, an X (1803), pp. 226-229 (type of genus, *molurus*).

Diagnosis: Maxillary, palatine and pterygoid bones movable; trans-palatine present; pterygoid extending to quadrate or mandible; supratemporal present, attached scalelike to skull, suspending quadrate. Both jaws with teeth, anterior ones of both jaws elongated and curved; a coronoid present; vestiges of pelvis and legs terminating in a clawlike spur visible on each side of vent. Head with enlarged scales; part of labials bearing pits; scales numerous, in 60-75 scalerows.

The three species of southeastern Asia may be distinguished by the following key:

KEY TO SPECIES OF *Python* IN THAILAND

1. Rostral and four upper labials on each side bearing pits; ventrals from about 300 to 332; subcaudals 75 to 102; very large elongate serpents reaching a length of 8 to 9 meters ..... *reticulatus*

   Rostral and two upper labials on each side with pits 2

2. Ventrals 245 to 275; subcaudals 58 to 75; large elongate serpent reaching a length of five to six meters ..... *molurus bivittatus*

   Ventrals 160-175; subcaudals 28-32; a much smaller shorter thicker serpent reaching to a length of about 2.5 meters ..... *curtus brongersmai*

Python molurus (Linnaeus)

Coluber molurus Linnaeus, Systema naturae, vol. 1, 1766, p. 387; *ibid.*, 10th Ed., 1758, p. 225 (type-locality, India); Andersson, Bih, Sv. Vet. Akad. Stockholm, vol. 24, 4, 6, 1899, p. 35.

Python molurus Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 246; Catalogue of the snakes in the British Museum (Natural History) 2nd Ed., vol. 1, 1893, pp. 87-88; Bourret, Les Serpents de l'Indochine, 1936, p. 18.

Two subspecific forms are recognized, the typical one *molurus molurus* in Ceylon and peninsular India, and *molurus bivitattus* Schlegel found in the Indo-Chinese Subregion, including southern China and Thailand.

Python molurus bivitattus Schlegel

(Fig. 8a)

Python bivitattus Schlegel (*part.*), Essai sur la physionomie des serpens, vol. 3, 1837, p. 403, pl. 15, figs. 1-4 (type-locality, restricted to Java).

Python molurus bivittatus: Mertens, Abh. Senckenb. Nat. Ges., vol. 42, 1930, p. 287, pl. VIII (type-locality fixed as "Java"); Pope, The reptiles of China,

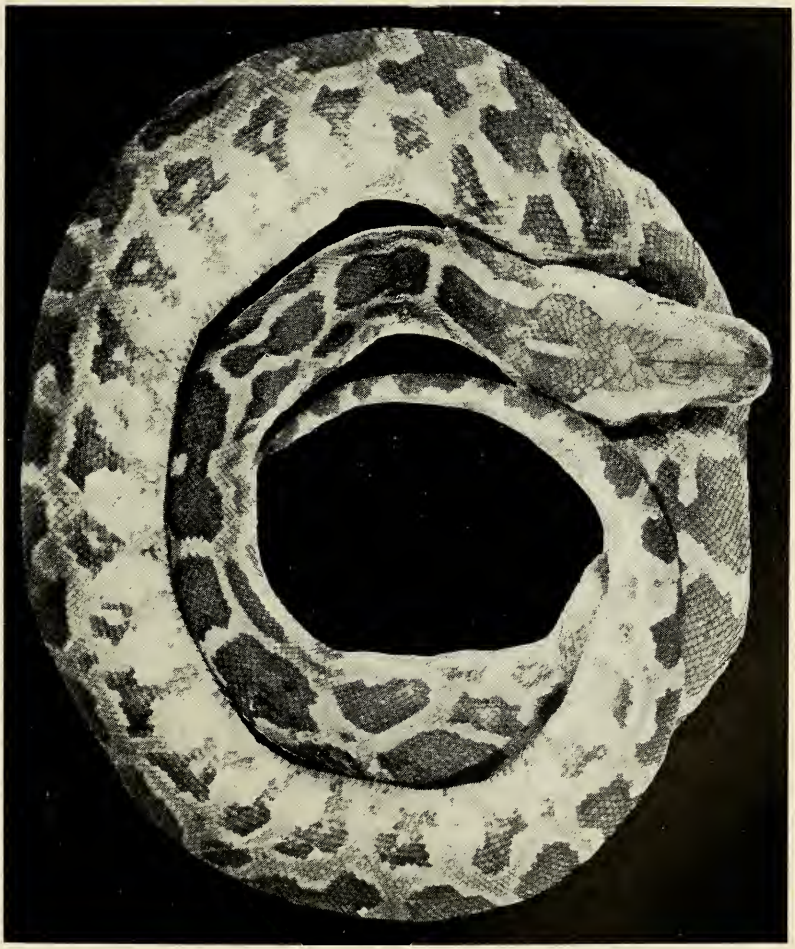

FIG. 8a. *Python m. molurus* Linnaeus. (From Taylor, Univ. Kansas Sci. Bull., vol. 33, pt. 2, 1950, pl. 13, fig. 1.)

1935, pp. 72-75. pl. 5; Bourret, Les serpents de l'Indochine, 1936, pp. 19-20, fig. 9; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 108-109.

Diagnosis: Large serpents; labials separated from eye by suboculars; arrow-shaped mark on head distinct; girth proportionally greater than in *reticulatus*.

Description of subspecies (composite): Nostril at upper posterior part of a large anterior nasal; rostral broader than high with two deep diagonally placed pits; a pair of internasals forming a median suture each longer than wide; a pair of enlarged prefrontals; these followed by a second pair of prefrontals; frontal divided longitudinally, each part about as wide as a supraocular; parietals fragmented; 12 supralabials first two bearing pits, separated from orbit by a row of suboculars; two preoculars; four loreals; two postoculars; about 20 infralabials, only two touching first pair of chinshields; four pairs of chinshields all very small, last pair widely separated from ventrals; pupil vertical; mental small, length of its labial border less than half that of rostral; scalerows around body (*molurus*) 61-75; ventrals, 242-265; subcaudals, 60-72.

Color: Ground color of yellowish brown or grayish brown; a dorsal series of large quadrangular, often somewhat elongated, reddish-brown black-edged spots; on each side a series of smaller spots with light centers; large spear-shaped dark mark from nape to tip of snout with an elongate cream or fawn spot on back of occiput, bordered laterally by a stripe of ground color; a dark stripe from tip of snout through eye widening on temporal region; a small brownish bar below eye; venter and chin yellow-cream; sides brown-spotted.

Measurements: Reaches a length of about 6.5 meters (*fide* M. Smith).

Distribution: Malcolm Smith reports three specimens taken in Thailand from the provinces of Raheng, Lop Buri, and Chon Buri (Siracha). Elsewhere the species occurs in southern China, Hong Kong, Hainan, and the whole Indo-Chinese subregion.

Python reticulatus (Schneider)

(Fig. 9)

Boa reticulata Schneider, Historiae amphibiorum naturalis et literariae, fasciculus secundus, 1801, p. 264 (based on Seba, Thesaurus, vol. 1, pl. 62, fig. 2, and vol. 2, pl. 79, fig. 1, the type-locality not recorded).

Python reticulatus: Gray, Zoological miscellany, 1842, p. 44; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 902; Günther, Reptiles of British India, 1864, p. 330; Boulenger, The fauna of British India . . . Reptilia and

Batrachia, 1890, p. 246; Catalogue of the snakes in the British Museum, vol. 1, 1893, pp. 85-86; Hagenbeck, Spolia Zeylanica, 1905, p. 197; Journ. Bombay Nat. Hist. Soc., vol. 16, Aug. 1905, pp. 505-506; (data from previous article); Sclater, List of the snakes in the Indian Museum, 1891, p. 4; Flower, Proc. Zool. Soc. London, 1899, p. 654; Ridley, Journ. Straits Branch Roy. Asiat. Soc., 1899, p. 196; Mocquard, Les reptiles de l'Indo-Chine, 1907, p. 42; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 107-108, fig. 32 (lower fig.); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, 1914, pp. 9-10 (Bangkok); Gairdner, *ibid.*, vol. 1, no. 2, Aug. 1914, pp. 125-126; M. Smith, *ibid.*, vol. 1, no. 3, Mar. 1915, pp. 155, 187, 213; *ibid.*, vol. 1, no. 4, Dec. 1915, p. 244 (Koh Chang); Werner, Arch. Nat. Berlin, vol. 87, 1921, p. 236; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 253; *ibid.*, vol. 31, 1926, p. 84; Kopstein, Trop. Natuur., 1927, p. 65; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 11, 1937, p. 61; Bourret, Les serpents de l'Indo-Chine, 1936, p. 16, fig.; M. Smith, The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 109-110.

Boa rhombeata Schneider, Historiae amphibiorum naturalis et literariae . . . vol. 2, 1801, p. 266 (based on Seba, Thesaurus, vol. 2, pl. 80, fig. 1).

Boa phrygia Shaw, General zoology, vol. 3, 1802, p. 348, pl. 97 (based on Seba, Thesaurus, vol. 1, pl. 62, fig. 2).

Coluber javanica Shaw; General zoology, vol. 3, 1802, p. 441 (type-locality, Java).

Diagnosis: Large serpents (28-30 feet); posterior head-scales small; three to five loreals; rostral with two pits, first four supralabials with single pits; 70 to 80 scales around middle of body; no enlarged chinshields; two or three anterior-and five or six posterior infralabials with pits; subcaudals divided.

Description of species (from No. 1692, Kanchanaburi): Rostral about as wide as high, narrowly visible above, with two large diagonal pits reached by sutures from first labials; a pair of large nasals forming a median suture; nostril dorsal, in posterior part of scale, entered by a suture arising at first loreal; a pair of internasals more or less fused to nasals with a median suture; two pairs of prefrontals, second pair broken into several scales; two or three loreals; two preoculars, upper largest; frontal partially broken anteriorly; supraoculars enlarged, irregular, broken on inner side; three postoculars; temporal scales small; supralabials, 13-14, first four with diagonal pits, seventh bordering eye; infralabials, 23-23; second to fourth or fifth with small pits. A mental groove but no well-defined chinshields. Pupil vertical. The parietal region covered with small scales; scales about neck at first ventral, 65; at mid-body, 72; before vent, 44. Ventrals, 322; subcaudals, 92 + 1 or 2; anal single.

Color in life: Above, head uniform brown growing light gray or dirty white on supralabials. A narrow black line begins on snout and runs back to nuchal region where it widens and termi-

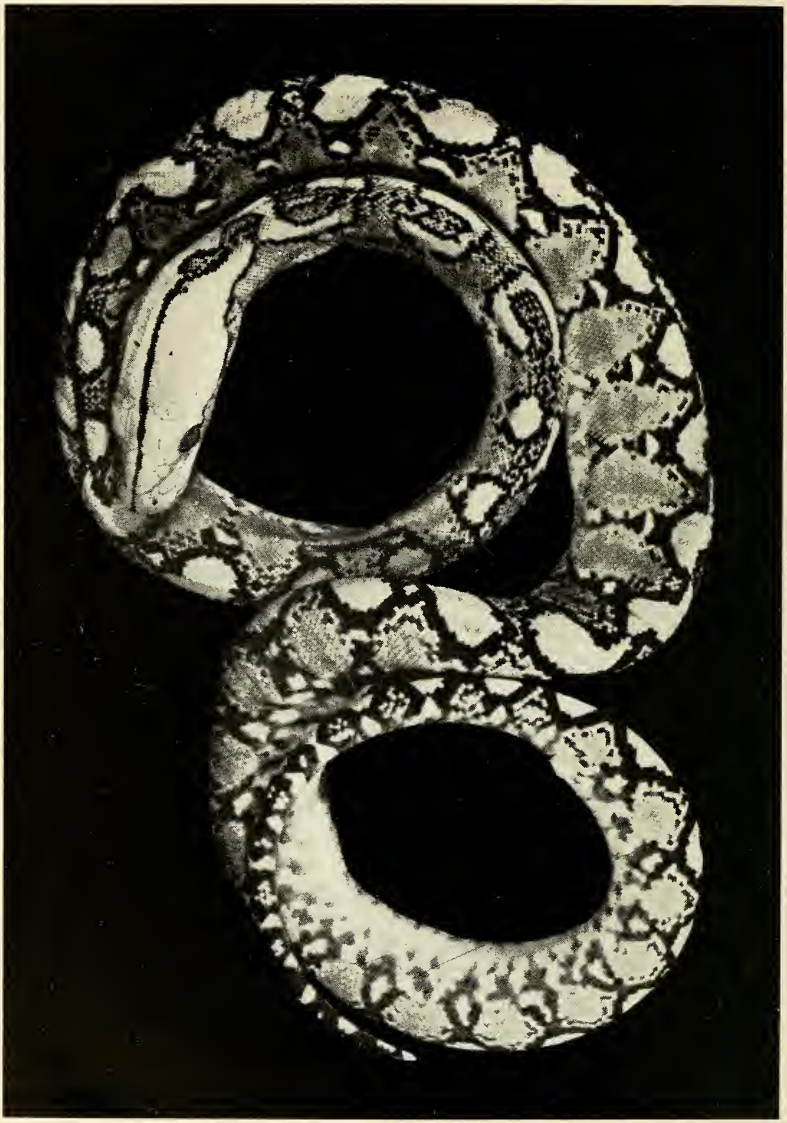

FIG. 9. *Python reticulatus* (Schneider). No. 34530. Pattani, Pattani province. Actual total length, 727 mm.; tail, 112 mm.

nates three centimeters back of head; a narrow black line from eye to back of head; chin and throat white with some indefinite blackish markings on infralabials anteriorly.

On each side of body a zigzag black stripe connecting across back with a similiar series on other side, enclosing along back a

series of somewhat oval brown spots edged with light brown; below the zigzag line, a series of ivory to yellowish spots with black spots above and below them; a second series of ocellated spots directly below first series.

More posteriorly the pattern takes on the appearance of a series of black rhombs, touching each other laterally, with a light brown edge about a darker center; ventrals throughout cream to ivory; enlarged scalerows near ventrals with black flecks and spots; subcaudal area black and white spotted.

Measurements in mm.: Total length, approximately 3560; snout to vent, 3084; tail, 476.

Variation: The sixth or seventh supraocular may border eye. There are usually two anterior infralabials bearing pits and five or six posterior infralabials with larger pits. Usually the internasals are free from the nasals.

The scalerows at the middle of the body vary from 70 to 80.

The range in ventrals and subcaudals are respectively: 297 to 332; 75 to 102; subcaudals usually divided.

Distribution: In Thailand the species is found throughout the country except perhaps in the northern parts. Elsewhere it occurs in Burma, much of Indo-China, Malaya, and the Indo-Australian Archipelago as far as the Philippines.

Remarks: In literature this creature is widely known as the python and is probably the largest (longest) serpent known. Specimens measuring 25 feet are not especially rare and specimens reaching a length of 30 feet have been reported, perhaps authentically.

The South American anaconda, also belonging to this family, closely approaches the size of the python, and where specimens of equal length are compared the anaconda may be the heavier and more bulky species.

Most if not all of the Oriental members of the family Boiidae are oviparous, while the new world species are chiefly ovoviviparous.

The python has been known to lay as many as a hundred eggs in a single clutch. The eggs are cared for, the female coiling about the eggs and remaining with them until the young are ready to hatch. The incubation period is said to range between 60 and 80 days.

Mr. John Hagenbeck writes (*loc. cit.*, 1905): "A gigantic python which arrived here last year from British North Borneo via Singapore laid about 100 eggs on the 28th of October, almost filling the

box in which she was kept. On the following morning she had collected the eggs by skillful movements of her body into a heap which she completely covered in such a manner that the weight of the body exerted no pressure upon the soft-shelled eggs.

"During the period of incubation I offered ducks, fowls, and geese to the python but she refused all nourishment.

"On the 14th of January she left the mass of eggs quite exposed, and I had given up hope of a successful issue when I discovered the first nestling with half its body emerging from the egg, into which, however, it retired again towards evening.

"The period of incubation lasted exactly two-and-a-half months. The young measures from two, to two-and-a-half feet long.

"Altogether forty-five young have been recovered from the clutch.

"So far as can be ascertained, the parent python measures about 28 ft. in length and weighs 250 lbs."

Python curtus Schlegel

Python curtus Schlegel, Dierentuin Gen. Nat. Amsterdam, Rept. 1872, p. 54; fig. — (type-locality, Sumatra); Hubrecht, Notes Leyden Mus., vol. 1, 1879, p. 244 (between Padang and Indrapura, Sumatra); Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 1, 1893, pp. 89-90; Zeneck, Tübinger Zool. Arbeit., vol. 3, no. 1, 1898, pp. 46-49, 140-143.

Python breitensteini Steindachner, Sitzb. Akad. Wien, vol. 82, 1881, p. 267; Fischer, Arch. für Naturges., 1885, p. 68, pl. 5, fig. 5 (type-locality, Borneo).

Aspidoboa curta: Sauvage, Bull. Soc. Philom, ser. 7, vol. 8, 1884, p. 143.

Three subspecies have been recognized by Olive G. Stull, *loc. cit.*, one of which occurs in Malaya and Thailand; this has been named as follows:

Python curtus brongersmai Stull

(Figs. 10, 11)

Python curtus Blanford, Proc. Zool. Soc. London, 1881, p. 222 (Singapore); Boulenger, Proc. Zool. Soc. London, Nov. 5, 1889, pp. 432-433, pl. 45 (in color; specimen from Malacca, Malaya).

Python curtus brongersmai Stull, Occ. Papers Boston Soc. Nat. Hist., vol. 8, Jan. 28, 1938, pp. 297-298 (type-locality, Singapore.)

Diagnosis: This form may be distinguished from *Python curtus curtus* Schlegel and from the Bornean form *Python curtus breitensteini* Steindachner by the presence of two supraocular plates instead of one; by the entrance into the orbit of two supralabials as compared to none (usually); and a higher average number of ventrals.

Description of species (composite): Rostral wider than high with two relatively deep transverse pits, the scale narrowly visible above; a pair of internasals, slightly longer than wide; two pairs of prefrontals, anterior smaller but equally as wide, forming a suture with its fellow equally as long as posterior pair; frontal segmented longitudinally the two together smaller than a supraocular; three pairs of parietals, posterior shortest; two preoculars upper very large; a series of suboculars; ten loreals on each side; ten supralabials, fifth and sixth bordering eye, first and second with deep pits; infralabials 19, second to fourth and tenth to fourteenth with shallow pits (third to fifth and twelfth to fourteenth on left side).

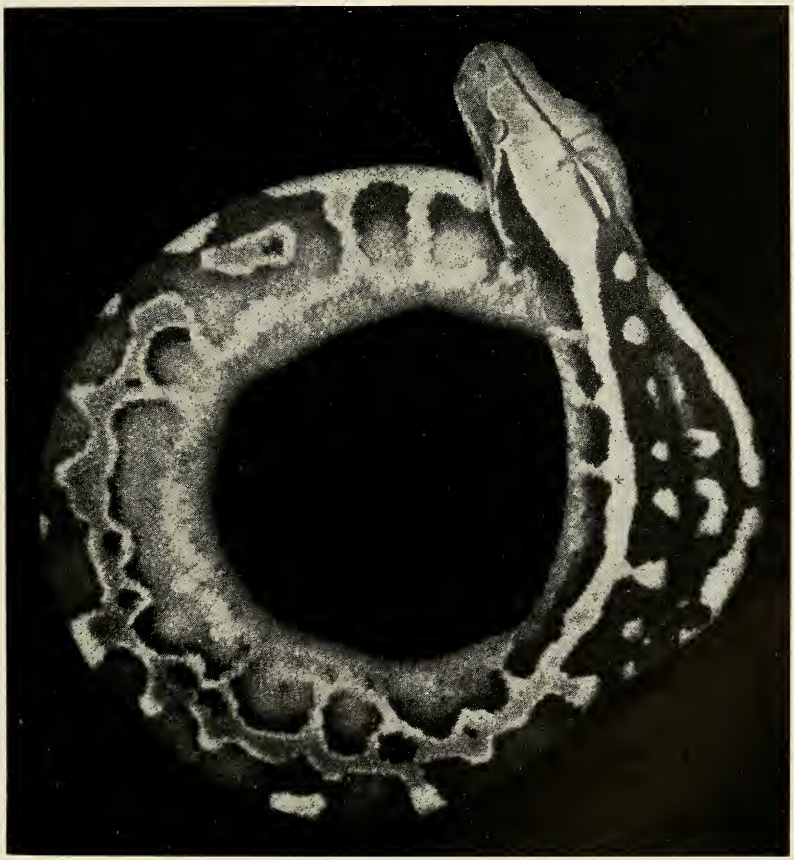

FIG. 10. *Python curtus* Schlegel. B.M. No. 86.5.15.35, Telang, S. E. Borneo. A little less than natural size. (This figured specimen is from Borneo and may or may not be the same subspecies as occurs in Malaya and Thailand)

Scalerow-formula: 51-55-33; ventrals, 174; caudals, 32 (divided).

Color: Above on upper part of dorsum somewhat reddish or orange-red; head somewhat lavender above with light lines on labial edges and another line from behind eye joining labial lines at jaw-angle; a row of cream or fawn-colored spots or spots joined tending to form a median extremely irregular lighter line; a fawn line from head dorsolaterally soon broken into irregular spots that may be more or less connected; a median series of fawn spots on latter fifth of body with darker lateral spots that may be connected; ventral areas cream.

Dentition: Mandibular teeth, 19; premaxillary, 2; maxillary, 19; palatine, 6; pterygoid, 13.

Measurements in mm.: Total length of type, 1180; tail, 112.

Variation: Stull (1938) states that: "Two specimens in the British Museum from Malacca and Kuala Lumpur, Malaya have the following scale counts (made by Dr. H. W. Parker): Scalerows at mid-body, 58, 54; ventrals, 170, 168; caudals, 28, 27; infralabials 19/19 (19-18); two preoculars; two postoculars, two supraoculars, and two supralabials entering the eye on each side."

Distribution: This form has been taken in Thailand only from the extreme southern part in Pattani. Elsewhere it is known from Singapore, the type-locality "Malacca," and Selangor (Kuala Lumpur).

Remarks: The young specimen figured (fig. 10) is B. M. 86.5.15.35, Telang, S. E. Borneo. It probably represents the Bornean *breitensteini.* There is but little color difference in the three forms. The distinctions between the three subspecies recognized by Stull have to do primarily with differences in scale-counts. Thus the ventrals of *brongersmai* average, 170.5, *breitensteini,* 162.5, *curtus,* 159.6, a total variation in averages of 11 ventral scales! There are other differences. The form *brongersmai* has the supraocular broken, and two supralabials bordering the orbit. The single Thai specimen of the peninsular form that I have seen (fig. 11) is a living one taken on Bukit Besar, Pattani and now in the collection of Nai Prayoon Kananuracks. It was not feasible to make scale-counts on the living specimen, and in consequence I am not certain that it agrees wholly with *brongersmai.*

The adults of this species are especially thick-bodied in proportion to their length. The head is proportionally small and short.

FIG. 11. *Python curtus brongersmai* Stuhl. From a living specimen photographed against the side of a box; Bukit Besar, Na Pradoo, Pattani, Pattani province. Length approximately 2.25 m. (Property of Nai Prayoon Kanaguracks, of Na Pradoo, Thailand. The lateral black marks on the side of the head are indistinguishable from the background making the head appear too narrow; see fig. 10.)

Tweedie (1954) states that "The Short Python is not uncommon in Malaya and is even more attached to water than the Reticulated [python]."

FAMILY DIPSADIDAE Günther

The generic name *Amblycephalus* Kuhl, (1822) applied to an oriental genus of snakes is untenable since it is preoccupied by *Amblycephalus* Zeder (1803), and cannot be used either as a generic name or used in forming a family name Amblycephalidae. The next generic name available is *Pareas* Wagler, and the resulting subfamily name would be Pareatinae.

Dr. James Peters who has recently reviewed a group of Central and South American species of the subfamily Dipsadinae does not commit himself to designating the family to which this subfamily belongs; one may presume that it is considered as a member of the Colubridae or Dipsadidae.

Concerning the Oriental group including the genera *Pareas* (1830) and *Aplopeltura* (1853) Malcolm Smith (1943) states: "Recent workers in this group have separated the American members from the Asiatic. The former can be connected through *Sibon* (= *Leptognathus*) *sibon* with the Colubrinae, while the Asiatic genera can-

not. The characters of the shields covering the lower jaws serve to distinguish them at once from all other snakes. Nevertheless, the two groups are closely allied to one another, and probably had a common origin. The mouth is peculiar in that the commisure extends far back beyond the fringe of the buccal membrane, while the short, high head and large eye bear a remarkable resemblance to a foetal snake. Another feature of the Dipsadinae is the enormous development of the nasal gland."

Since the oldest applicable generic designation is *Dipsas* it should be used for the family name, and the Oriental subfamily name would be Pareatinae.

Subfamily PAREATINAE

This subfamily includes two genera, *Pareas* and *Aplopeltura*, which may be distinguished by the following key:

KEY TO ORIENTAL GENERA OF THE PAREATINAE

1. Scales in 15 rows; subcaudals paired ..... *Pareas*
2. Scales in 13 rows, subcaudals single ..... *Aplopeltura*

Genus *Pareas* Wagler

Amblycephalus (not of Zeder 1803) Kuhl, Isis, 1822, p. 474 *nomen nudum;* Boie, Isis, 1827, p. 519; (type of genus, *Amblycephalus laevis*).

Pareas Wagler, Natürliches System der Amphibien . . . 1830, p. 181 (type *Pareas carinatus*); Theobald, Descriptive catalogue of the reptiles of British India, 1876, p. 203.

Eberhardtia Angel, Bull. Mus. Hist. Nat. Paris, vol. 26, p. 291 (type of genus *Eberhardtia tonkinensis* = *Pareas hamptoni* (*fide* Malcolm Smith).

Diagnosis: Head very short, thick, distinct from neck; snout blunt; eye large or very large with a vertical pupil; body, especially in arboreal forms, much compressed, tail becoming very slender behind vent; scales in 15 rows throughout body; subcaudals paired; ventrals not angulate. Maxillary short, thin, expanded vertically, with four to nine subequal teeth, the front part lacking teeth; anterior mandibular teeth large, decreasing in size posteriorly; prefrontal bone with a backward prolongation more or less completely roofing orbit; no mental groove, anal single.

The genus occurs in southeastern Asia, the Malay Peninsula, and Archipelago.

There are six species recorded from Thailand, three of which also occur in Malaya. The other three are continental forms that are known either in Burma or Indo-China.

KEY TO SPECIES OF *Pareas* IN THAILAND

1. Vertebral scales not enlarged; body not strongly compressed; labials separated from orbit by subocular; terrestrial 2
   Vertebral scales of median row (sometimes adjoining rows also) more or less enlarged; body strongly compressed arboreal 3
2. Scales smooth, usually with, or without an interrupted neck-band; ventrals less numerous ..... *margaritophorus*
   Scales keeled, usually with an irregular neck-band; ventrals more numerous ..... *macularius*
3. Labials separated from eye by one or more suboculars 4
   Labials not separated from eye, two or three border orbit 5
4. A single elongate subocular (sometimes fused to postocular) ..... *hamptoni*
   Two to eight suboculars ..... *carinatus*
5. Six supralabials, third and fourth (sometimes fifth also) border orbit; third infralabials forming a median suture with each other ..... *laevis*
   Seven supralabials, third and fourth border orbit; second or third infralabial joining its fellow to form a median suture ..... *malaccanus*

Pareas margaritophorus (Jan)

(Fig. 12)

Leptognathus margaritophorus Jan, Nouv. Arch. Mus. Hist. Nat. Paris, vol. 2, 1866, p. 8 (type-locality, Siam); Morice, sur la faune de la Cochinchine Française, 1875, p. 60; Bocourt, Nouv. Arch. Mus., Paris, 1886, p. 9.

Pareas margaritophorus: Theobald, Catalogue of the reptiles of British India, 1876, p. 203; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 1-104; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 117.

Amblycephalus margaritophorus: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 445; Flower, Proc. Zool. Soc. London, 1899, p. 694; Mocquard, Rev. Coloniale, 1907, p. 48; Boulenger, Ann. Mag. Nat. Hist., ser. 8, vol. 14, 1914, p. 485 (Key); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, p. 215; Werner, Arch. Naturg. Band 87a, Heft 7, 1922, p. 194; Bourret, Invent. Gen. Indochine, 1927, p. 238; Les serpents de l'Indochine, vol. 2, 1936, p. 434.

Pareas moellendorffi Boettger, Ber. Offenb. Ver., 1885, p. 125; *ibid*, 1888, p. 84, pl. 2, fig. 1 (type-locality, Lo-fou-shan Mts., Canton); Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 37.

Amblycephalus moellendorffi: Boulenger, Catalogue of the snakes of the British Museum, vol. 3, 1896, pp. 443-444; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 210-211; Laidlaw, Proc. Zool. Soc. London, 1901, 2, p. 581; Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 170; Smith, Journ. Nat. Hist. Soc. Siam., vol. 1, no. 3, 1915, p. 215 (*moellendorffi*) and Journ. Siam Soc., Nat. Hist. Suppl., vol. 6, Oct. 1923, p. 204; Wall, Rec. Ind. Mus., vol. 24, 1922, p. 23; Journ. Bombay Nat. Hist. Soc., vol. 30, 1925, p. 245; Smith, Bull. Raffles. Mus., no. 3, 1930, p. 88 ("very common at Bangnara, Patani according to Mr. C. J. Agaard"); Pope, Reptiles of China, 1935, p. 373; Bourret, Les serpents de l'Indochine, 1936, pt. 2, p. 433; Tweedie, Bull. Raffles Mus., Singapore, no. 23, 1950, pp. 191-192.

Diagnosis: Prefrontal not excluded from eye; dorsal scales smooth. Loreal separated from the eye by one or two preoculars; eye separated from labials by a subocular; ventrals, 138-159.

Description of species (from No. 34422): Body somewhat compressed; head thickened, distinct from neck, snout blunt, truncate; depression about and behind nostrils; eye large, pupil vertical; area in front of eye swollen; rostral wider than high, excavated below, narrowly visible above; internasals wider than long, narrowly in contact laterally with loreal; prefrontals double size of internasals,

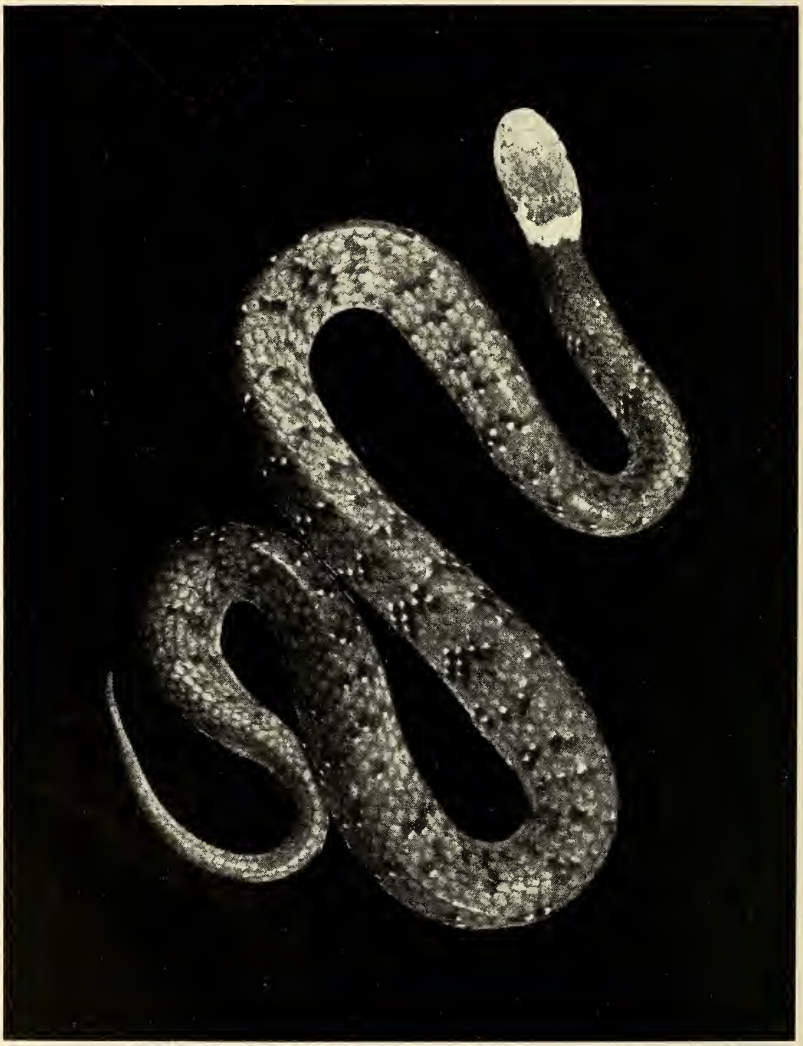

FIG. 12. *Pareas margaritophorus* Jan. EHT-HMS No. 1356♀, Bukit Besar (Mt.), (near waterfall), Na Pradoo, Pattani, province, southern Thailand. Actual total length, 290 mm.; tail, 48 mm.

entering orbit above preocular; frontal subtriangular about as wide as long, slightly shorter than its distance from tip of snout, much shorter than parietals; supraoculars small, subtriangular, side bordering orbit slightly curved; parietals much longer than wide, as long as their distance to tip of snout, much narrowed posteriorly. Temporals, three, followed by three, all narrow elongate; two upper scales in first series touch suborbital, the lower pushed back behind sixth labial; nasal scale large, subquadrangular, the nostril pierced in the posterior part; loreal longer than high; preocular triangular, not touching supraocular; "suborbital" a narrow curving scale extending from preocular, below and behind eye where it is in contact with supraocular; seven supralabials, second to fifth in contact with suborbital; seven infralabials; four bordering first very large chinshields; mental separating first labials and in contact with chinshields; second pair of chinshields make a narrow median suture; third pair triangular, in contact at a narrow point; no groove between chinshields.

Scales entirely smooth, in 15, 15, 15 rows (19 across occiput); ventrals, 146 not angulate; anal single, subcaudals, 51. The tail suddenly becomes very slender a short distance behind vent.

Color: Head variegated lavender-brown, lighter on labials; a pair of black spots behind parietals and smaller less distinct spots at mouth angle preceded by a white area; rostral and dorsal head scutes darker; a cream-white ring about neck (interrupted dorsally on left side) about three scales wide, and followed by a dark band; body generally light brown but darker on anterior fourth of body and neck; a series of very narrow transverse bars, one scale wide, consisting of scales marked in front with cream, and behind with black; laterally they may widen, and rarely divide; venter gray-white, irregularly spotted or flecked with black, the spots not confined to outer part of ventrals, the subcaudal area most strongly marked; chin and neck dirty cream.

Measurements in mm: Total length, 320; tail, 69; head-width, 7.1; head-length, 13.

Variation: The older specimens, according to Theobold (1868) tend to lose the transverse markings and become a uniform ochraceous-brown. It is significant that the scale that I have called the "suborbital" is divided, in the material studied by Blyth and Theobald, into "five, six, or seven small shields which exclude the labials from the orbit." It is possible that his reference is to another species.

In the young specimens the neck-band is mottled with claret-red or orange. The length of one adult is approximately 600 mm. of which 112 mm. is the approximate length of the tail.

Two specimens were acquired in 1961 from two widely separated localities, EHT-HMS, No. 1356 ♀ (figured) from Bukit Besar (near waterfall), Pattani province, and EHT-HMS No. 3923 ♀ , 10 km. N. Chiang Dao, Chiang Mai province. These display the following differences:

No. 1356 has three temporals on each side, the two upper touching the large subocular (which is fused to the postocular), the lower one is separated from it and is divided vertically into two scales. The first pair of infralabials form a strong suture behind the mental. The reddish-orange nuchal ring, from two to three scales in width, is complete, followed by a dark band. The ventrals are 149; subcaudals, 41. The venter is gray with numerous scattered gray dots.

No. 3923 has the temporals arranged two over one (elongate), over two. There are two touching the subocular. The first infralabials do not touch behind mental. On one side there are two loreals. In this specimen the collar is incomplete, consisting of an orange spot covering part of eight scales with two median black dots. Ventrals, 153; subcaudals, 39. Otherwise the two specimens agree in color and markings save that No. 3923 has the venter yellow-ivory with many ventrals bearing a small subquadrangular spot on outer ends and only a few scattered punctate dots.

Distribution: The species is known in Thailand from Pattani, Narathiwat, and Chiang Mai.

Elsewhere it is reported from Burma, South China, Indo-China and the northern part of Malaya.

Remarks: The specimen from Bukit Besar was found in a roadside drain, under a small mass of wet leaves. I suspect that subspecies will be designated for some of the variants of this species but much more material is desirable before this is undertaken.

Pareas macularius Blyth

(Fig. 13)

Pareas macularius Blyth, in Theobald, Journ. Linn. Soc., vol. 10, Zoology, no. 41, 1868, pp. 54-55 (type-locality, Martaban, S. Burma); M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 480; The fauna of British India, Ceylon, and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, p. 118; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1126-1128, fig. 21.

Amblycephalus macularius: Boulenger, The fauna of British India, 1890, pp. 416-417; Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 444-445; Wall, Rec. Ind. Mus., vol. 25, 1922, p. 24; Journ. Bombay Nat. Hist. Soc., vol. 30, 1925, p. 245; vol. 31, 1926, p. 566.

Pareas andersonii Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 6, 1888, p. 601, pl. 5, fig. 3 (type-locality, Bhamo and Kakhyen Hills, Burma; *fide* Smith); separate of same, p. 9.

Pareas tamdaoensis Bourret, Bull. Gen. Inst. Publ. Hanoi, vol. 10, 1935, p. 11 (type-locality, Tam Dao, Tong-King, *fide* Smith); Les serpents de l'Indochine, vol. 2, 1936, p. 431.

Diagnosis: Resembles *Pareas margaritophorus* in color and markings but differs from it however in having a more compressed body. There are keels on five or seven median scalerows, and a somewhat larger series of ventrals and subcaudals.

Description of species (from EHT-HMS No. 31798 ♀, Thailand): Rostral large, slightly wider than high, its upper edge, as seen from above, a straight line; internasals more than twice as wide as long, notching upper edge of nasal, narrower than prefrontals; latter

FIG. 13. *Pareas macularius* Theobald. EHT-HMS No. 31798 ♀, Thailand. Actual total length, 210 mm.; tail, 49 mm.

wider than long, touching preocular and loreal, entering orbit; frontal short, six-sided, its length a little greater than width, slightly longer than its distance from tip of snout, shorter than parietals; latter scales longer than their distance from tip of snout; nostril in a single nasal, somewhat triangular; loreal about as wide as high; one preocular, one postocular; a large narrow curving subocular; supraocular not longer than eye; temporals, 2 + 3, but irregular in second (and third) rows; seven supralabials, four or three touching subocular, last much the longest; mental small, touching first pair of chinshields, separating first labials from one another; eight (seven) infralabials, four (five) touch first chinshields which are longer than wide; second and third pairs transversely widened; no groove under chin; first ventral touching third pair much larger than following ventrals; eye higher than its distance from mouth; 20 scales across back of head; 15 rows at neck, middle of body, and before vent; ventrals, 163; subcaudals, 55 paired; anal single; mandibular teeth, 29, the anterior five times as large as the posterior teeth.

Color: Top of head heavily speckled with brown; a pair of black spots behind parietals; diagonal brown line from upper level of eye to mouth angle; on sixth and seventh labials a suggestion of a second line; brown flecks on supralabials; a somewhat zigzag cream nuchal band crosses occiput and nape and merges with light color of chin and throat behind jaw angle; cream band followed by a W-shaped black mark; general body color brown with approximately 60 transverse rows of scales with black dots, each dot bordered anteriorly by cream, the rows irregular and often incomplete. Outer part of ventrals and subcaudal region flecked with brown.

Measurements in mm.: Total length, 210; tail, 49.

Pareas hamptoni Boulenger

Amblycephalus hamptoni Boulenger, Journ. Bombay Nat. Hist. Soc., vol. 11, 1905, p. 236, pl.—(type-locality, Mogok, Burma); Ann. Mag. Nat. Hist., ser. 8, vol. 14, 1914, p. 485; Parker, Ann. Mag. Nat. Hist., ser. 9, vol. 15, 1925, p. 305; Wall, Rec. Ind. Mus., vol. 24, 1922, p. 26; Journ. Bombay Nat. Hist. Soc., vol. 30, 1925, p. 245.

Pareas hamptoni: M. Smith, Ann. Mag. Nat. Hist., ser. 10, vol. 6, 1930, p. 681; Rec. Ind. Mus., vol. 42, 1940, p. 480; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, Dec. 1943, p. 120 (N. E. Siam, near Pak Lai, lat. 18° upper Mekong, etc.)

Eberhardtia tonkinensis Angel, Bull. Mus. Hist. Nat. Paris, vol. 26, 1920, p. 291, figs. 1-3 (type-locality, Laokay, Hong-King), and *ibid.*, ser. 2, vol. 1, 1929, p. 80.

Amblycephalus tonkinensis: Bourret, Les serpents de l'Indochine, vol. 2, 1936, p. 428, fig.; Pope, The reptiles of China, 1935, p. 378, fig.;

Amblycephalus carinatus hainanus M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 204 (type-locality, Hainan).

Amblycephalus carinatus berdmorei: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 88 (*part.*).

Diagnosis: A small species, vertebral scales enlarged; body strongly compressed; frontal shorter than parietal; prefrontal entering eye. Head sharply distinct from neck; one preocular; loreal excluded from eye, or barely touching it.

Description of species: Snout short, blunt; rostral a little higher than wide; internasals about half as long as prefrontals; prefrontals entering orbit; frontal longer than its distance from end of snout, shorter than parietals; loreal as high as long, or a little higher, not or scarcely touching eye; one preocular; one postocular; a long crescentic bandlike subocular connecting pre- and postocular or postocular also united with subocular; temporals, 2 + 2 or 2 + 3; seven or eight supralabials, fourth and fifth below middle of eye; scales in 15 rows, scales smooth or median rows slightly keeled; vertebral series, and sometime adjoining rows feebly enlarged; ventrals, ♂ 191-196; subcaudals, 93-98; of female, ventrals 180-194, subcaudals 73-87.

Color: Similar to *monticola.* Brown above with vertical blackish bars on sides or sometimes extending across back; a black line from above eye to nape, and another from behind eye to angle of mouth; top of head more or less thickly spotted with black; yellowish below, dotted brown.

Remarks: The species is seemingly rare in Thailand. Malcolm Smith's records it from "near Pak Lai lat. 18° upper Mekong," N. E. Thailand, and under the name *Amblycephalus carinatus berdmorei,* he reports the species as being common at "Bangnara" (= Narathiwat, Narathiwat), Thailand. Elsewhere it is known in northern Burma, Tong-King, Annam, and Hainan.

Pareas carinatus Boie

(Fig. 14)

Amblycephalus carinatus Boie, Isis, 1828, p. 1035 (type-locality, Java); Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 445-446; Barbour, Mem. Mus. Comp. Zool. Harvard Col., vol. 44, 1912, p. 138 ("Bangnara, Patani"); Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, pp. 163-164; Wall, Rec. Ind. Mus., vol. 24, 1922, p. 25; J. Bombay Nat. Hist. Soc., vol. 30, 1925, p. 426; Bourret, Les Serpents de l'Indochine, pt. 2, 1936, p. 435, fig.

Pareas berdmorei Theobald, Catalogue of the reptiles in the Asiatic Society's museum, 1868, p. 63 (type-locality, Tenasserium).

Pareas carinatus: Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 37 (Bang Suk, near Pak Jong, Thailand); M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 121; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1128, 1130, fig. 22 (Loei province).

Amblycephalus carinatus berdmorei: Smith, Bull. Raffles Mus., no. 3, 1930, p. 88 (in *part.*).

Diagnosis: Body strongly compressed; vertebral scales somewhat enlarged or not; frontal as long or longer than parietal; prefrontal does not border orbit; head distinct from neck; separated from eye by from two to eight suboculars.

Description of species (from EHT-HMS No. 3626, 10 km. N. Chiang Dao): Body strongly compressed, tail prehensile; head large, distinct from neck; upper lips flaring out. Rostral higher than wide (2½ x 3½ mm.), not, or but scarcely visible from above; internasals triangular, much wider than long, their mutual suture longer than that between prefrontals and forming a suture with the loreal nearly as long as that with rostral; prefrontals a half wider than long, touching loreal and preocular laterally, narrowly separated from eye; frontal with the sides nearly parallel, much wider than supraoculars, longer than its distance to end of snout, slightly shorter than parietal; nasal single, longer than high, nostril pierced in posterior part; loreal higher than long, touching second supralabial and two preoculars of which upper one is highest but widely separated from frontal; one postocular; supraocular touches the postocular and upper anterior temporal; parietals scarcely larger in area than frontal, bordered laterally by four temporals and posteriorly by five postparietals; two or three suboculars separating supralabials from orbit; supralabials, 8-7, first four higher than wide, last two longer than high, the last about three times as long as wide; infralabials, 9-8, first forming a postmental suture, first four bordering first chinshields and first supralabial on left side; mental as wide as rostral; three unequal pairs of chinshields followed by a large azygous scale much larger than first ventral; eye large, its diameter greater than its distance from anterior part of snout. Three anterior temporals, four secondary temporals, somewhat irregular.

Scalerows: 20 (occiput), 15, 15, 15, the median dorsal row (vertebrals) not or scarcely enlarged; ventrals, 174; anal undivided; subcaudals, 72, all save the ultimate divided; several median scalerows keeled.

FIG. 14. *Pareas carinatus* (Boie). No. 3626, 10 km. north of Chiang Dow, Chiang Mai province, northern Thailand. Actual total length, 488 mm.; tail, 108 mm.

Color: Head light brown on top and in temporal region, with some black dots. Rostral, supralabials, chin, ventrals, subcaudals and outer scalerow yellowish ivory a little more yellow anteriorly. A more or less connected black line arises back of eye passes back along temporal region to side of neck, narrowly separated from its fellow from opposite side; a hair-fine black line from lower part of eye to lip, crossing subocular, lower anterior temporal and the last two supralabials; on dorsum generally light or olive brown with about 71 transverse darker marks crossing body, these rather indistinct, and usually the width of one scalerow, formed by separate blackish marks on scales and somewhat more scattered pigment; outer edge of ventrals with some fine dots or flecks of dark pigment and a more or less definite row of dark dots; transverse dark marks dim on tail, the subcaudal dots more scattered.

Measurements in mm.: Total length, 488; tail, 108; width of head, 11; length of head, 16; depth of head, greatest, 9.

Variation: A specimen from Loei province has 77-78 bands (different on two sides) while those on a female specimen from the same province are so dim they cannot be counted. The temporals may have a fairly regular arrangement of 3 + 3 + 4 or 3 + 4 + 4. There are five small ocular scales in both of these specimens while there are six in the described form on one side.

The ventrals in five specimens examined (one unnumbered, from an uncertain Thai locality) vary from 158 to 181; the subcaudals from 68 to 72 (Malcolm Smith reports 170-184 for ventrals, subcaudals 60-80).

Data on *Pareas carinatus*

NUMBER	31796	31797	3626
Locality	Loei	Loei	Chiang Mai
Total length	430	522	488
Tail	41+	111	108
Width of head	10	11.2	11
Length of head	16.2	19	16
Scalerows at middle	15	15	15
Ventrals	181	178	174
Subcaudals	26+	71	72
Preoculars	1–1	1–1	2–2
Postoculars	1–1	1–1	1–1
Suboculars	3–3	3–3	3–3
Supralabials	7–7	6–7	8–7
Infralabials	8–9	8–5	9–8

Distribution: The species is widely distributed in Thailand, specimens having been taken in the provinces of Chiang Mai (Chiang Dao), Loei, Narathiwat, and Nakhon Si Thammarat (Khao Luang Mt.).

Outside of Thailand it is known in Burma, the Indo-Chinese region from Lat. 19° N, south throughout Malaya and the Indo-Australian Archipelago. Certain subspecies have been described that may be worthy of retention.

Pareas laevis Boie *in* Boie

Pareas laevis Boie, *in* Boie, Isis, 1827, p. 520 (type-locality, Java); Günther, The reptiles of British India, 1864, p. 328; Tweedie, The Snakes of Malaya, 1954, p. 54, (Northern Malaya).

Amblycephalus laevis: Boulenger, The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 415; Catalogue of the Snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 441-442; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 209; Laidlaw, Proc. Zool. Soc. London, 1901, 2, p. 581; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia 1917, p. 276; M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 88 ("Khao Ram in the Nakhon Si Thammarat mountains").

Diagnosis: Small snakes reaching a length of 545 mm., the body strongly compressed; no preocular; loreal and prefrontal entering eye; two or three labials bordering orbit; first chinshield undivided, in contact with mental; third infralabial large touching its fellow; two pairs of large chinshields broader than long; brown with irregular dark crossbands; sides orange, venter brown or yellowish, spotted with brown or with transverse brown spots on sides.

Description of species: Rostral broader than high; prefrontals entering eye; frontal as long as broad or a little broader than long, as long as, or a little longer than its distance from end of snout, two thirds as long as parietals; supraocular very small; loreal elongate bordering orbit; no preocular, one or two postoculars; temporals, 2 + 2; six supralabials third and fourth (third, fourth and fifth) bordering orbit, sixth very long; mental in contact with first undivided chinshield; third infralabial very large forming a suture with its fellow; a small azygos chinshield followed by two pairs of large chinshields, broader than long.

Scales in 15 rows throughout, smooth, vertebral row enlarged; ventrals, 148-176, anal, single, subcaudals, 34-59. Eye large; no longitudinal groove under chin.

Color: Brown above with irregular transverse blackish crossbands; sides dull orange; lower parts brownish or yellowish, spotted with brown or with transverse brown spots on sides.

Measurements in mm.: Total length, 545; tail, 65.

Remarks: The species has been collected only once in Thailand. Dr. Malcolm Smith found it on Khao Ram in Nakhon Si Thammarat. The species, while having a distribution in Sumatra, Java and Borneo, appears to be absent in the lower part of the Malay Peninsula. (Data chiefly from Boulenger, 1912, and Smith, 1930.)

Pareas malaccanus (Peters)

Asthenodipsas malaccana Peters, Monatsb. Akad. Wiss. Berlin, 1864 p. 27, pl. —, fig. 3. (type-locality, "Malacca").

Amblycephalus malaccanus: Boulenger, Catalogue of the snakes in the British Mus., 2nd Ed., vol. 3, 1906, pp. 442-443; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 209-210; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 276-277 (Sumatra, Borneo, Mentawei Islands); M. Smith, Bull, Raffles Mus., no. 3, Apr. 1930, p. 88 (Bhetong, "Patani" = Yala province).

Pareas malaccanus: Tweedie, The Snakes of Malaya 1954, p. 36.

Diagnosis: Small snakes, reaching half a meter in length; no preocular; loreal and prefrontal bordering eye; two postoculars; third and fourth labials bordering orbit; second and third infralabials very large in contact mesially with each other; yellowish or pale brown above with rather irregular dark-brown cross-bars interrupted mesially.

Description of species: Rostral a little broader than deep; frontal as long as broad or a little broader than long, as long as or a little longer than its distance from tip of snout, much shorter than the combined parietals; supraocular small; prefrontal and loreal entering orbit; no preocular; two postoculars; temporals, 2 + 2 the two upper ones sometimes fused; seven upper labials, third and fourth bordering orbit, seventh enlarged; mental in contact with a small azygous scale; second and third infralabials very large, usually in contact mesially on chin; two pairs of large chinshields, broader than long; no mental groove.

Scales in 15 rows, smooth, the three median rows a little enlarged; ventrals, 154-170; anal, single; subcaudals, 26-55.

Color: Yellowish or pale brown above, with rather irregular dark-brown cross-bars which are interrupted on back; vertebral scales yellowish; head sometimes whitish; sides and lower surface of neck black; belly whitish, uniform or speckled with dark brown.

Measurements in mm.: Total length, 440; tail, 50.

Distribution: The species has been taken in Thailand only at Bhetong in Yala province. It also occurs in Malaya, Sumatra and Borneo.

Remarks: Malcolm Smith states that the Bhetong specimen had only the median dorsal scalerow enlarged. Boulenger has suggested that the type-locality should be "Malay Peninsula," rather than "Malacca."

Genus *Aplopeltura* Duméril and Bibron

Aplopeltura Duméril and Bibron, Mem. Acad. Sci. Paris, vol. 23, 1853, p. 463 (type of genus, *Amblycephalus boa* Boie).

Haplopeltura Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 439 (emendation).

Diagnosis: Head strongly distinct from neck; eye large with vertical pupil; nasal undivided; body strongly compressed with long tail. Scales smooth in 13 rows without pits; vertebrals enlarged; costal scales placed somewhat obliquely; subcaudals single; no mental groove.

Maxillary short, thin, expanded vertically, with five subequal teeth preceded by a short space without teeth; 12-13 mandibular teeth, decreasing in size posteriorly; skull with a wide vacuity between parietal, frontal and sphenoid bones.

Only a single species is recognized. The genus is widely distributed from the Philippines throughout the Malay Peninsula and Archipelago.

Aplopeltura boa (Boie)

(Fig. 15)

Amblycephalus boa Boie, Isis, 1828, p. 1034 (type-locality, Java); Günther, Catalogue of colubrine snakes, 1858, p. 184; The reptiles of British India, 1864, p. 325.

Dipsas boa: Schlegel, Essai sur le physionomie des Serpents, vol. 2, 1837, p. 284, pl. 11, figs. 29, 30; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 925, pl. 40, fig. 3.

Aplopeltura boa: Duméril, Bibron and Duméril Erpétologie générale, vol. 7, 1854, p. 444; Smith, Bull. Raffles Mus., no. 3, 1930, p. 88 ("hills to the east of Chumporn = [Chumphon] . . . 1000 ft. elev.").

Haplopeltura boa: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 439-440; Flower, Proc. Zool. Soc. London, 1899, p. 693; Boulenger, Fasciculi Malayenses, Zool., vol. 1, 1903, p. 170; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 208; Taylor, Dept. Agri. Nat. Res. Bureau of Science, Pub. 16, Feb. 11, 1922, pp. 280-283, pl. 34, figs. 7-9 (head); Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 122 (Nakhon Si Thammarat, Chumphon); Tweedie, The snakes of Malaya, 1954, p. 36-37, fig. 6c (head).

Diagnosis: Slender compressed snakes reaching a length of 750 mm.; snout short, head thickened; two (or three) enlarged occipital scales; two or three loreals; a preocular, several suboculars and a postocular; two pairs of infralabials meet behind mental. Scales in 13 rows, vertebrals enlarged; subcaudals single. The color var-

iable from yellowish-gray to brown, blotched, mottled, or clouded with lichen-green or brownish red; below yellowish, mottled with brown.

Description of species (from P.K. No. 101, Na Pradoo, Pattani [near Bukit Besar] Thailand: Rostral narrowly visible above, somewhat more than one-and-one-half times as high as wide, with a high-arched notch at its base, above which the scale is depressed or excavated; internasals extended transversely, suture between scales about one third as long as transverse length of scale (left internasal abnormally broken, the severed part having the appearance of a loreal); prefrontals large, their common suture little less than half width of one scale; frontal hexagonal, sides nearly parallel, anterior and posterior parts having same shape but anterior slightly

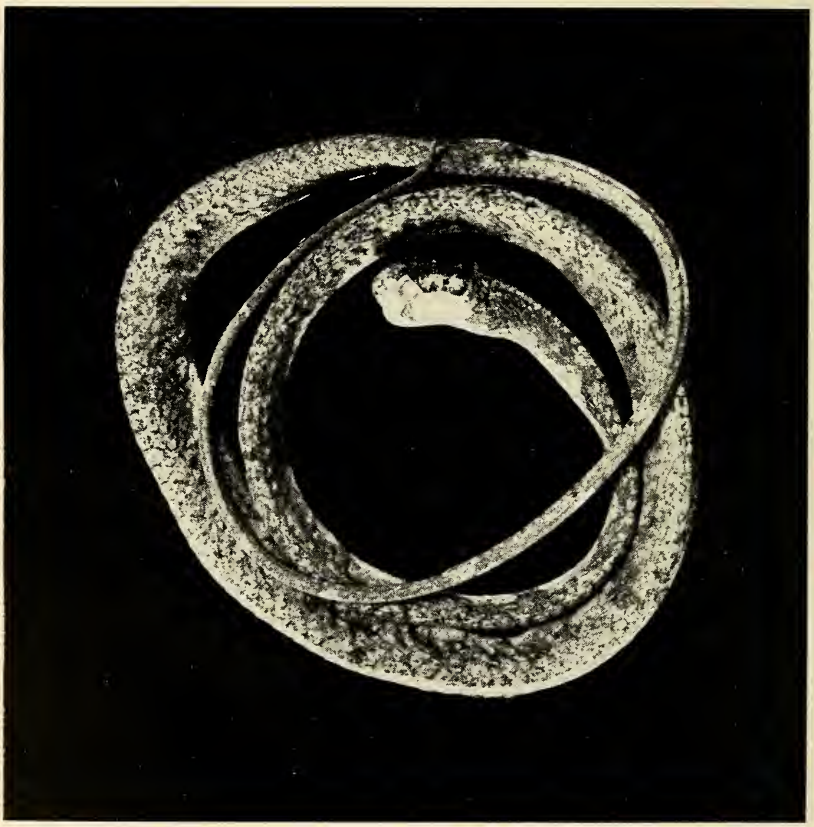

FIG. 15. *Aplopeltura boa* (Boie). P.K. No. 101, Na Pradoo, Pattani province, southern Thailand. Actual total length, 719 mm.; tail, 223 mm.

wider; length of frontal equal to or a little greater than its distance from tip of snout and equally as long as parietals; latter scales relatively small with an elevation near middle; pair of enlarged occipital scales bordering parietals.

Nostril pierced in a single triangular nasal; three loreals of different sizes, upper largest; two distinct preoculars, two postoculars, upper largest; three suboculars; supraocular large bending outward behind eye, with a slight curved emargination on outer edge immediately above eye; three rows of irregular temporals, upper anterior largest, bordering upper postocular; nine (or ten) supralabials, separated from eye by suboculars. Mental small with two pairs of infralabials in contact with each other behind mental; eleven infralabials, posterior one largest; no mental groove present; chinshields followed by two azygous scales, and these followed by three pairs of chinshields which are large but somewhat irregular.

Scale-formula: 26 (bordering occiput), 13, 13, 13; median scale series enlarged; lateral scales narrow, elongate, somewhat oblique; ventrals, 165½; anal single; subcaudals, 108, all single.

Eye large, its diameter equal to its distance from snout-tip; pupil vertical; maxillary teeth five, preceded by a short vacant space, the teeth subequal; 12 (13) mandibular teeth, anterior ones very large, fanglike, diminishing posteriorly in size. Tongue with longitudinal black lines. Head large, much thickened, sharply set off from body.

Color: Above brownish gray with indefinite dark markings and flecks of black; lower on sides mottled with irregular smoky-black blotches; venter generally lichen-gray with some cream color. Head with a conspicuous cream-white spot covering most of the side of face in front of eye; snout tip with numerous blackish flecks; a large blackish spot covers occipital, supraocular and interorbital areas, bordered laterally, behind orbits, with a yellowish stripe that is bordered below by a broken black band; a vertical black mark from eye to lip.

Measurements in mm.: Total length, 719; tail, 223; width of head, 10.5; length of head, 20.

Distribution: The species is widespread, extending from Mindanao, Palawan, and Balabac in the Philippines, through Borneo, Java, Sumatra, Malaya, and Peninsular Thailand.

In Thailand specimens are known from Bukit Besar (mt.), Pattani, Nakhon Si Thammarat, and Chumphon. The described specimen is from Na Pradoo at the base of Bukit Besar.

Variation: The known variation reported in the literature for ventrals is 148 to 191; subcaudals 88 to 127. Scale counts for mainland specimens given by Malcolm Smith (1943) is 166-175 for ventrals, 106-122 for subcaudals. There may be three or two pairs of chinshields and eight to ten supralabials.

The largest specimen, a female, measures 835 mm. in total length; the tail-length being 265 mm.

The wide range with concomitant variation suggests the probability that subspecies occur which merit recognition.

Remarks: The single specimen taken in Thailand and reported by Dr. Malcolm Smith (1943) was colored in life as follows: "pale gray with narrow black cross-bars or almost complete bands; top of head and vertebral scales red, the former speckled with black."

A specimen taken in Agusan province, Mindanao, Philippines was discovered in a small lichen-covered dead tree. When it fell to the ground around an accumulation of dead twigs, it remained motionless in the same position in which it had fallen, and was picked up in this semirigid condition. It was seemingly mimicking the lichen-covered twigs and small branches, since its color resembled markedly that of the twigs.

FAMILY COLUBRIDAE COPE

The family Colubridae contains a large proportion of the living serpents of the world, the bulk of which are without poison and of those with poison-glands and grooved teeth, very few are of danger to man. The family has been broken up into several subfamilies. In this work I have treated the Thai forms in seven subfamily groups. The degree of differentiation in these groups is doubtfully of equal value. They may be differentiated by the following key.

KEY TO THAI SUBFAMILIES OF THE COLUBRIDAE

1. No ventral shields; aquatic snakes (fresh and salt water) with from 100 to 150 small juxtaposed scales around middle of body; ..... *Acrochordinae*
   Ventral shields widened; hypapophyses present or absent on posterior dorsal vertebrae 2
2. Dentary bone detached from articular posteriorly; teeth ungrooved, numerous, 30 to 50 in each maxilla and closely set, equal in size, often subspatulate or bayonet-shaped; hypapophyses throughout the vertebral column, terrestrial ..... *Sibynophinae*
   Dentary bone not detached from articular posteriorly 3
3. Aquatic snakes (fresh and marine waters), maxillary teeth 10-22, some usually enlarged, grooved, fanglike; nostril crescentic on dorsal surface of snout; hypapophyses developed throughout the vertebral column, all (except *Cantoria*) proably not exceeding a meter in length .... *Homalopsinae*
   Terrestrial serpents. Nostril not crescentic, not situated on dorsal part of skull 4

4. A supraorbital bone; scales completely or almost completely attached to the cutis, and separated from one another by naked skin; head-shields granular or shields normal; labials usually with everted margins; nostril in a concave shield; maxillary teeth 15-35, none grooved or fanglike, *Xenoderminae*

No supraorbital bone; scales normally not separated by naked skin, not attached alone to the cutis; maxillary teeth with or without grooved fangs 5

5. Maxillary teeth, ten to eighteen, the last two or three teeth grooved and fanglike. Hypapophyses present or absent on posterior dorsal vertebrae; mostly arboreal snakes, none completely aquatic ..... *Boiginae*

Maxillary teeth 6-33 without grooves; some may develop enlarged posterior fanglike teeth 6

6. Hypapophyses present throughout the vertebral column (*Natrix, Rhabdophis Pseudoxenodon Macropisthodon Parahelicops, Opisthotropis*) *Natricinae*

Hypapophyses absent in posterior vertebrae *Gonyosoma, Elaphe, Ptyas, Lycodon, Dinodon, Oligodon, Liopeltis, Dryocalamus, Calamaria, Plagiopholis, Pseudorhabdion, Ahaetulla* ..... *Colubrinae*

Subfamily XENODERMINAE Cope

Xenoderminae Cope, Ann. Rept. National Museum 1898 (1900) p. 731. M. Smith, Ann. Mag. Nat. Hist., ser. 11, vol. 3, Mar. 1939, pp. 393-395; Werner Mitt. naturh Mus. Hamburg, vol. 26, 1909, p. 206); The fauna of British India, Ceylon and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 123.

Malcolm Smith, *loc. cit.* has placed the following genera in this subfamily: *Xenodermus, Nothopsis, Stoliczkaia, Fimbrios* and *Achalinus*, genera, most of which formerly had been considered in the *Acrochordinae*. Of these only a single genus and species is known in our territory. This is *Xenodermus javanicus*, known in Thailand from two specimens taken by me in the province of Yala near the La Doo Tin Mine, Bendang Stah.

Genus *Xenodermus* Reinhardt

Xenodermus Reinhardt, Overs. Viden. Selsk. Forh., 1836, p. 6 (type of genus, *javanicus*).

Gonionotus Gray, in Stoke's, Discovery in Australia, vol. 1, 1846, p. 502, (type, *plumbeus*).

Diagnosis: Body slender, feebly compressed. Scales varied in middorsal region: a median series of somewhat enlarged scales alternating with smaller scales; the two adjoining series equally enlarged, but scales not contiguous in row, separated by two or more very small scales; a dorsolateral series of enlarged, somewhat elongated scales, separated from each other by small scales; scales on flanks small, larger as they approach ventrals, the scales for the most part separated from each other by skin.

Maxillary with 15 equal teeth; pupil vertical; internasals and prefrontals present, but remainder of head covered with very small

granular scales bearing keels; tail elongated, with undivided subcaudals. Zygapophyses expanded laterally.

Only a single species is known. It ranges in the Malay Peninsula from southern Tenasserim, Thailand, and Malaya and extending to the islands of Java, Sumatra, and Borneo. It is said to be common at an elevation of from 500-1100 meters altitude in central Java, living in wet earth below the surface of the ground. It feeds chiefly on frogs. The species is ovoviviparous.

Only two specimens are known to have been taken in Thailand.

Xenodermus javanicus Reinhardt

(Fig. 16)

Xenodermus javanicus Reinhardt, Overs. Viden. Selsk. Forh., 1836, p. 6, (type-locality, Java); K. Danske Vidensk Selsk. Skrift, vol. 10, 1943, p. 257, pl. 2, figs. 1-8; Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 175; M. Smith, Ann. Mag. Nat. Hist., ser. 11, vol. 3, 1939, p. 393; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 44-45, figs. 24-25; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 40; Tweedie, The snakes of Malaya, 1954, p. 37, (Penang and Perak, Malaya).

Diagnosis: See diagnosis of genus.

Description of species (from No. 1350, La Doo Tin Mine, Benang Star [Bendang Stah], Yala). Rostral subtriangular, not reaching top level of snout, and not visible above, with a keellike elevation along lateral edges; nasal scale single but with an entrant suture from behind; nostril lunate, a deep depression on posterior part of scale, its back edge flaring up; upper edge with a keellike ridge; two nasals meetings mesially on front of snout; a pair of internasal scales lying back of nasal on upper surface of snout, widening mesially and in contact with each other, their posterior edges keeled; these followed by a pair of larger prefrontal scales, narrowly separated anteriorly by a single scale, the two diverging posteriorly, separated by several small scales; 17 or 18 small supralabials; remainder of head covered with small keeled juxtaposed tubercular scales, about 20 rows between eyes; several scale series lying above supralabials, those following nasals, and scales in frontal area somewhat larger; about 24 minute scales around eye, the three or four above eye largest; mental very small, broadly triangular; first pair of infralabials in contact behind mental; a pair of distinguishable chinshields separated by a row of granules; 21-22 infralabials, a little better differentiated from other scales than supralabials; 13-14 scales between chinshields and first ventral; 88 tubercular scales around head at first ventral; 58 to 60 scales at middle of body; 44 in front of vent.

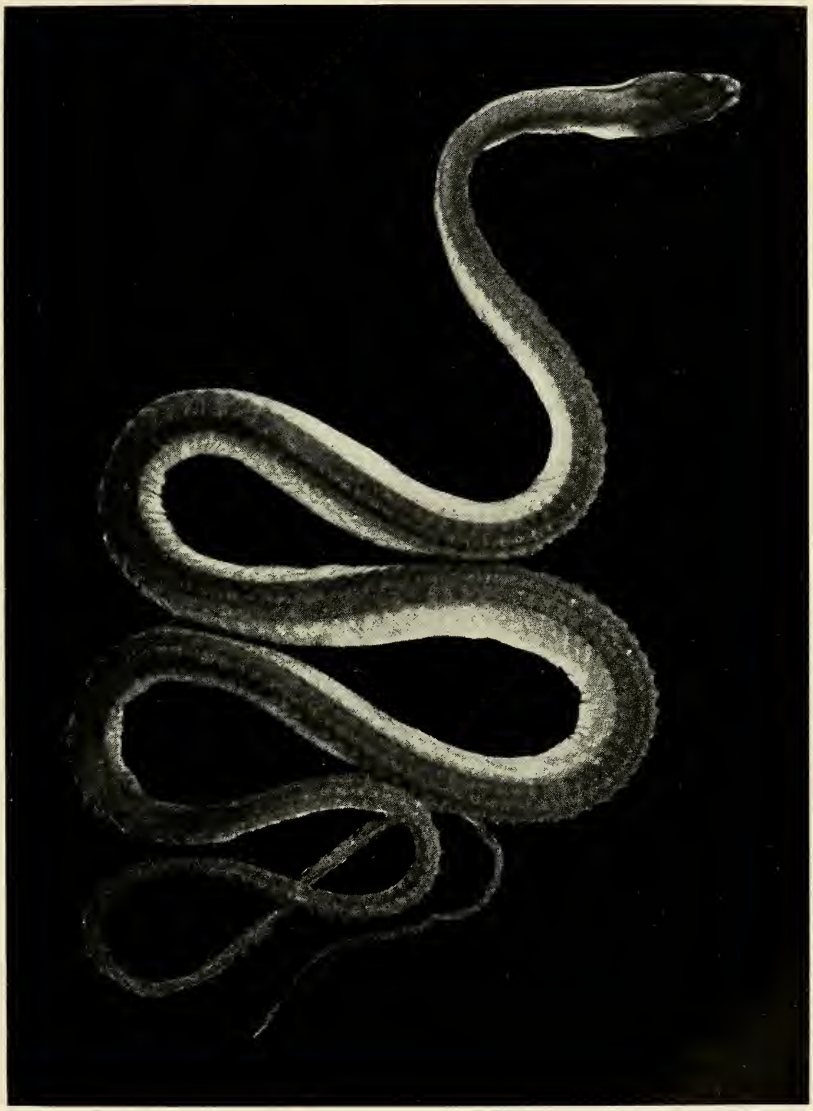

FIG. 16. *Xenodermus javanicus* Reinwardt. No. 1350, La Doo Tin Mine, Yala, southern Thailand. Actual total length, 433 mm.; tail, 282 mm.

Three specialized median scalerows, that in the middle composed of alternating large and small scales, the larger ones more or less alternating with a pair of scales somewhat lateral to it; scales of the two bordering rows are not in contact; a few small scales intercalated among the three rows; separated from these median rows by five or six small granular scalerows is a dorsolateral discontinuous

row of scales about half as large as the median rows, the scales longer than wide, separated each from the other by from one to three granular scales; below this row seven or eight irregular rows of fine granules, and below this growing a little larger as they approach ventrals are eleven or twelve rows of scales more or less separated by naked skin; anteriorly the scales of the median rows are small, gradually increasing in size for some distance. Most body scales keeled.

Ventrals, 172 + 1 pair; anal single; subcaudals single, 113; a widely separated pair of scales precedes first subcaudals (the tip of the tail has been injured). (A second specimen, No. 1372 ♂ has the ventrals, 169 + 1 pair; anal single; 124 single subcaudals, posteriorly narrowing, becoming notched then compressed, and keeled with slight terminal mucrones).

Color in life: Head brownish, tip of snout blackish with some whitish marks on nasals and rostral; dorsum brown, light dove-gray on sides; venter gray, each ventral with a transverse gray-brown mark along its anterior edge; subcaudals barred with brown; chin and throat whitish and a whitish mark bordering the anterior ventrals.

Measurements in mm. (Nos. 1350 and 1372). Total length, 433, 386; snout to vent, 282, 243; tail, 151, 143; width of head, 7.5, 6.4; length of head, 11.5, 10.

Variation: The number of scales round the body varies between 40 (*fide* Boulenger 1912) and 60 in the specimen described; M. Smith (1930) reports a Burmese specimen with 170 ventrals, 120 subcaudals and 60 scales around body. The specimen is a female.

The known variation in ventral counts is from 170 to 185; the subcaudals from 124 to 165. The snake reaches a length of 453 mm. The tail length is 228 mm.

Distribution: These two specimens taken at the La Doo mine are the only ones that have been found in Thailand. Elsewhere one specimen has been found in southern Burma, and there are two records for Malaya (Penang and Perak). The species occurs also in Sumatra, Borneo, and Java.

Remarks: The species is reported as being found in Java, burrowing in cultivated land at an elevation of 3000 ft., always near water. The specimen herewith described was found coiled in a soggy rotten log in a stream; it was discovered when the log was kicked to pieces. It was rolled into a ball in a cavity and it remained more or less in a ball after it was picked up and examined.

The other specimen likewise was obtained by kicking to pieces a similar log in the same rivulet, a few hundred feet higher at an elevation of about 2500 ft.

Subfamily SIBYNOPHINAE Dunn

Remarks: The subfamily of the Sibynophinae consists of three genera, *Sibynodontophis,* confined to Centeral America, *Parasibynophis* confined to Madagascar, and *Sibynophis* to the Oriental Region.

Snakes of this group appear to effect autotomy when the tail is grasped by a predator. This would account for the fact that a large proportion of captured specimens have incomplete tails. (See Taylor and Elbel, 1958.)

Genus *Sibynophis* Fitzinger

Sibynophis Fitzinger, Systema reptilium, 1843, p. 26 (type *Herpetodryas gemminatus*).

Polyodontophis Boulenger, The fauna of British India including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 301. (Substitute name for *Enicognathus* preoccupied.)

Diagnosis: Dentary loosely attached, and completely detached posteriorly from end of articular. Teeth very numerous on maxillary, palatine, pterygoid, and dentary, closely set, of approximately the same size; head scarcely distinct from neck; pupil round. Body cylindrical, the ventrals without lateral keels or notches; paired subcaudals; hypapophyses developed throughout vertebrae; anal divided. Oviparous.

Three species occur in Thailand: *Sibynophis melanocephalus* Gray, a southern, peninsular form; *S. collaris* (Gray) seemingly widely distributed; and *S. triangularis* Taylor and Elbel which ranges in southeastern Thailand, Indo-China, and north into Assam.

KEY TO SPECIES OF *Sibynophis* IN THAILAND

1. Tenth supralabial much the largest; black triangular nuchal spot, bordered laterally by a cream or yellow stripe continuous with cream lines on labials ..... *triangularis*

   Tenth supralabial not largest, nuchal dark band not triangular 2

2. Ten supralabials, eighth much the largest; two postoculars, only upper touches parietal; temporals, $1 + \frac{1}{1+1}$ ..... *collaris*

   Nine supralabials; temporals, 2 + 2; two preoculars, both touch parietal; ventrals, 144-169; subcaudals, 120-145; brown or blackish above with two lighter yellowish or bluish-gray longitudinal streaks, each of which may bear a series of black spots ..... *melanocephalus*

Sibynophis melanocephalus (Gray)

(Fig. 17)

Lycodon melanocephalus Gray, Illustrations of Indian zoology, vol. 2, 1834, pl. 83, fig. 2, (type-locality, Singapore?).

Herpetodryas prionotus Cantor, Proc. Zool. Soc. London, 1893, p. 52, (type-locality "Malacca").

Ablabes melanocephalus: Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858; The reptiles of British India, 1864, p. 229.

Polyodontophis geminatus: (*part.*), Boulenger, Catalogue of the snakes of the British Museum (Natural History), vol. 1, 1893, pp. 185-186; A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore; Reptilia and Batrachia, 1912, pp. 120-121 (*part.*); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, 1917, pp. 54-55 (*part.*); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 158 ("Bangnara, Patani").

Sibynophis melanocephalus: Tweedie, The snakes of Malaya, 1954, pp. 63-64; Batchelor, Malay Nat., vol. 12, pp. 103-112.

?*Sibynophis geminatus insularis:* Mertens, Senckenbergiana, vol. 9, 1927, pp. 240-241, (type-locality Sabana, North Sumatra).

Sibynophis geminatus: Sworder, Singapore Nat., 1922, p. 60 (Singapore); M. Smith, Bull Raffles Mus., no. 3, Apr. 1930, p. 40 (Narathiwat, Thailand).

Diagnosis: A median dark stripe flanked by two lighter stripes that bear small transverse spots or bars; ventral scales with an influx of lateral color, and a series of black spots on outer part of ventrals. Scales in 17 rows; nine supralabials, fourth and fifth touching eye.

Description of species (from P.K. No. 106 *, Na Pradoo, Pattani, southern Thailand): Rostral more than twice as broad as high, visible above as a narrow line, the outer lower edges of scale somewhat free and tending to overhang mental and two adjoining infralabials; internasals broader than long, more than half size of prefrontals, touching both nasals; prefrontals much wider than long, touching posterior nasal, loreal, and preocular laterally; frontal longer than wide, its length equal to its distance from posterior edge of parietals, greater than its distance from end of snout; parietals elongate, bordered behind by five body-scales, laterally by two temporals, posterior much elongate; nostril between two nasal scales, of which posterior is larger and higher than anterior; loreal small, a little higher than wide; preocular larger than loreal, barely reaching upper surface of head; supraocular large, as long as frontal but less wide; two postoculars, both touching parietal; temporals 2-2, lower anterior largest; both anterior temporals in contact with lower postocular.

* Collection of Nai Prayoon Kananuracks.

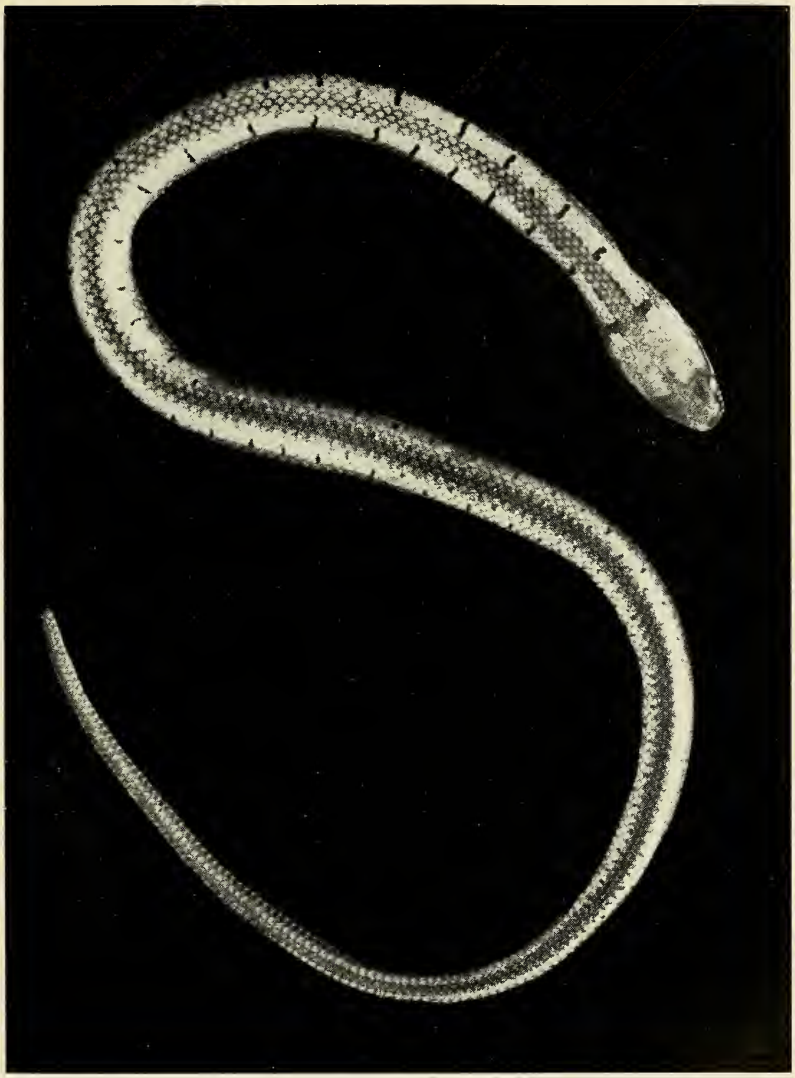

FIG. 17. *Sibynophis melanocephalus* (Gray). P.K. No. 106, Na Pradoo, Pattani; actual length, 288 mm.; tail, 58 + mm. (part missing).

Nine supralabials (eight on left side due to fusion of fifth and sixth), last very large but bordering for only a short distance on mouth; eight infralabials, first pair narrowly in contact behind small triangular mental; four infralabials touching first chinshields which are larger but nearly same length as second pair. Scales smooth without apical pits.

Scale-formula: 24 (occiput), 17, 17, 17; ventrals, 146, anal divided; subcaudals, 32 + (tail defective, part missing).

The maxillary teeth small, subequal, 44-44; ptergopalatine, 45-46; mandibular, 45-40 ±, all with brown tips.

Color: Body with a median dark blackish-brown median stripe covering three median scalerows and edges of adjoining rows, the stripe darkening anteriorly and posteriorly; on either side of this a light yellow-brown stripe, with a series of dark spots or bars often alternating, becoming darker posteriorly, and nearly black anteriorly; brown below this on sides, the color extending onto ventrals, touching a series of deep-black dots which extends from a point an inch behind head to end of tail. Head and occipital region for a distance of about half an inch (8 scales) blackish with faint light flecks; a black line, irregular in width, on sides of neck; posterior labials cream-white with black edges above and some darker flecking below; anterior labials dark, each with a whitish area; infralabials and entire chin faintly clouded with fine pigmentation; throat and venter yellowish-white.

Measurements in mm. (P.K. Nos. 106, 107 respectively): Snout to vent, 288, 128; tail, part missing, 58, 53; width of head, 7.8, 5.5; length of head, 13, 10.

Variation: Only two Thai specimens are available to me, the second being a juvenile from the same locality as the one described. There are 148 ventrals; the anal scale is divided, and there are 117 subcaudals. The posterior part of the body shows the darkening as in the described specimen but the head and neck are lighter. The posterior dorsal head scales are light brown, somewhat darker between the eyes, then somewhat lighter on snout. The scales have some whitish spots and their borders are gray or black. The chin is darker than in the described adult. The rows of black spots are indicated but not clearly marked anteriorly.

Distribution: In Thailand the species is known only in Narathiwat and Pattani. It is reported as being common in the lowlands of Malaya by Tweedie (Snakes of Malaya, 1954, pp. 63-64).

Remarks: Tweedie has stated that Dr. L. D. Brongersma has established the fact that the snake S. *geminatus* (Boie) is a species distinct from this one and it is probably confined to Java. He states that the correct name for this Malayan snake, which is also found on the islands of the Sunda Shelf, is S. *melanocephalus.*

Dr. Mertens has described a subspecies *geminatus insularis* which may actually belong to *melanocephalus,* (Senckenbergia, vol. 9, 1927, p. 240.).

Sibynophis triangularis Taylor and Elbel

(Fig. 18)

Sibynophis collaris triangularis Taylor and Elbel, Univ. of Kansas, Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1130-1134, fig. 23 (type-locality, Nongko, Sriracha, Chon Buri province, Thailand).

Sibynophis collaris (*part.*) Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 277-278.

Diagnosis: Related to *Sibynophis collaris;* a cream-line from rostral extends along the labials and meets its fellow on median nuchal region, widening posteriorly; postoccipital black spot triangular; a median row of quadrangular black spots interspersed with white spots; a lateral light line extends from neck some distance along the fourth lateral scalerow.

Description of species (from type description): Rostral three-fifths times as high as wide, narrowly visible above; internasals a little wider than long, their posterior borders curving, laterally narrowed, touching loreal; frontal a little wider than supraocular (4 mm. x 2.5 mm.), longer than its distance from end of snout; parietals longer than wide, about equal to their distance from rostral; nasal scale divided or at least partially divided with a vertical depression following nostril, posterior portion higher than anterior, touching two supralabials; loreal small, longer than high, touching two supralabials; a large preocular, higher than wide; ten supralabials, fourth, fifth, and sixth enter orbit; sixth and seventh touch lower postocular; a single anterior temporal touches eighth; tenth and last much the largest of series; two postoculars; parietal touching only upper postocular which is nearly square; temporal formula, $1+\frac{1}{1+1}$; nine infralabials, fourth largest, first four touching first chinshields which are larger than second pair; scales smooth.

Scalerows, 17-17-17; ventrals, 160; anal, divided; subcaudals (incomplete), 49.

Color: Generally grayish brown with a fawn line beginning on neck at level of eleventh ventral, following fourth and part of fifth scalerows; somewhat farther back it becomes discontinuous forming tiny elongate or rounded spots on upper half of fourth scalerow,

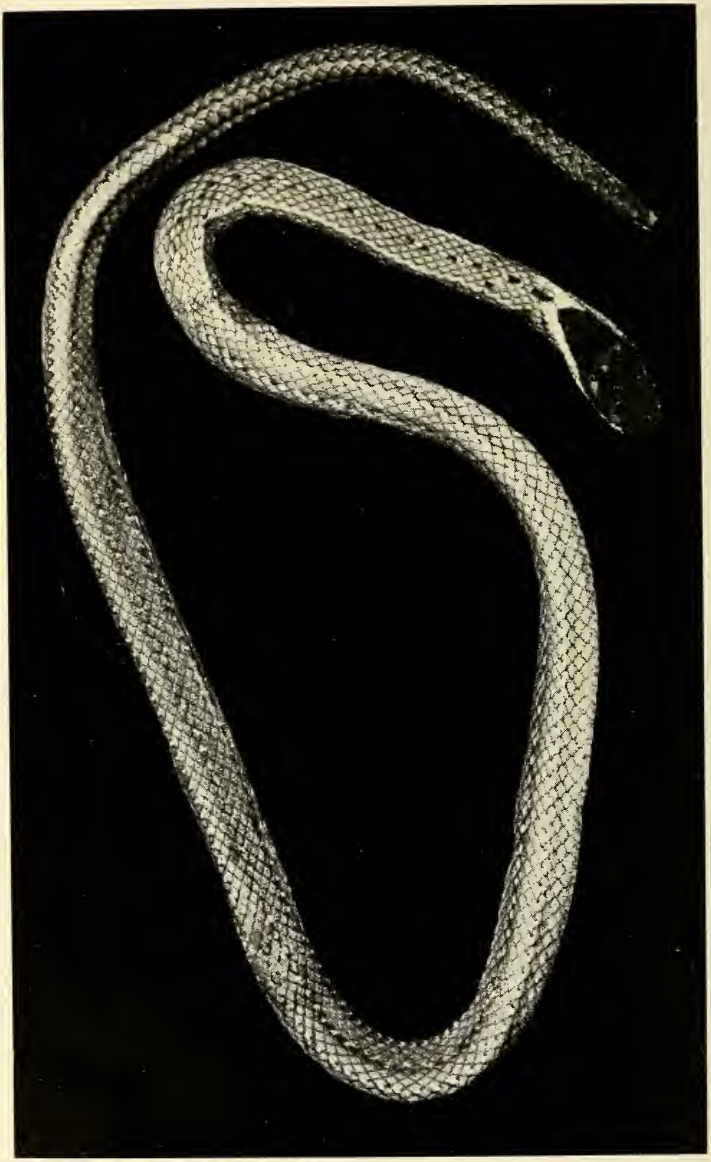

FIG. 18. *Sibynophis triangularis* Taylor and Elbel. Type. KUMNH, No. 33520, Nongko, Sriracha, Chon Buri province, Thailand. Actual total length, 327 mm. (From Taylor and Elbel.)

sometimes including part of adjoining scale in fifth row; pigment surrounding these spots becoming somewhat blackish; on middorsal line a row of small black spots extends a short distance; farther back a discontinuous series of white dots begins and continues posteriorly; these finally become nearly obsolete but they can be traced on to tail; ventral surface whitish with a discrete rounded black spot on outer edge of each ventral and subcaudal; outer turned-up part of ventrals pigmented like lateral body scales.

Head variegated olive with brownish-black spots, one or two on each head scale; an indefinite transverse dark band across back of frontal and supraoculars. A second somewhat indefinite curving band bordering parietals and temporals, joining deep black triangular nuchal spot and this enclosing an olive area; a cream-line from rostral passes back across labials and meets its fellow on medial nuchal region; this bordered above with black on labials; on lower part of some labials black spots present; anterior part of infralabials light brown with darker-edged cream spotting.

Maxillary teeth, 49-47; mandibular teeth, 53-52; palatine-pterygoid series, 53-53.

Measurements in mm.: Snout to vent, 239; tail (mutilated), 88; head-width, 8.15; head-length, 14.

Distribution: Known certainly only from southeastern Thailand in the province of Chon Buri. Malcolm Smith (1943) states: "Specimens [of *collaris*] from Siam and Annam may have a lateral series of yellow spots on scale-row 4 or 5, and the yellow border on the nape may be chevron-shaped, the apex pointing backwards."

I suspect that these may be referable to *triangularis*.

Remarks: Originally Taylor and Elbel (1958) regarded this a subspecies of *Sibynophis collaris*. Since the two forms are found together through a wide range it seems wiser to regard each as of specific rank. I have not been able to obtain further specimens of this species.

Sibynophis collaris (Gray)

(Figs. 19, 20)

Psammophis collaris Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 390 (type-locality, Khasi Hills, Assam).

Polyodontophis collaris: Boulenger, Fauna of British India . . . Reptilia and Batrachia, 1890, p. 302; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 184, pl. 12 (*part.*); Annandale, Rec. Ind. Mus., vol. 8, 1912, p. 46; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 316; *ibid.*, vol. 19, 1909, p. 340, 757; *ibid.*, vol. 29, 1923, p. 598; M. Smith,

Journ. Nat. Hist. Soc. Siam, vol. 1, 1914-1915, pp. 129, 155, 212; *ibid.*, vol. 1, no. 4, 1915, p. 244 (Koh Chang); Fraser, Journ. Bombay Nat. Hist. Soc., vol. 39, 1937, p. 498.

Ablabes collaris: Stoliczka, Journ. Asiat. Soc. Bengal, vol. 40, 1871, p. 430.

Sibynophis collaris: Smith, Bull. Raffles Mus., no. 3, 1930, p. 40; Rec. Ind. Mus., 42, 1940, p. 482; Pope, Reptiles of China, 1935, p. 86, fig.; Bourret, Les serpents de l'Indo-Chine, 1936, p. 43 (*part.*); Shaw, Shebbeare and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 13, 1939, p. 115; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 277-278, fig. 94, A, B, C, D (*part.*).

Diagnosis: One anterior temporal touching eighth labial; all ventral scales with a black dot on outer edges; anterior ventrals also with an inner central pair of dots; nape with a transverse black bar bordered behind with white or yellow, little less than width of a single transverse scalerow; a whitish series of spots on anterior labials becoming elongated dashes, and more or less continuous posteriorly.

Description of species (from No. 54, Doi Suthep, Chiang Mai): Rostral twice as wide as high, visible above for half its height; internasals subcircular in form, less than half size of prefrontals which are strongly rounded behind; frontal shield-shaped, longer than its distance from tip of snout, shorter than parietals; supraoculars longer than frontal; nostril between two nasals, posterior part highest; loreal a little wider than high; large preocular; eye large, pupil circular, diameter of eye equal to its distance from front edge of nostril; two postoculars; ten supralabials, fourth to sixth bordering eye; eighth and tenth much enlarged; nine infralabials, mental triangular; first labials in contact; first chinshields larger but about as long as second pair.

Scale-formula: occiput (at fifth ventral), 23; neck, 18; middle of body, 17; before vent, 17. Ventrals, 176; anal divided; subcaudals, 116, divided.

Color in life: Head dark olive with a pair of blackish spots surrounded by tiny yellow dots on rostral, one each on internasals, prefrontals, and supraoculars; minute yellowish punctations on parts of parietals and frontal (distinct under a lens); dim interocular dark band and a similar band behind occiput, bordered behind by a dotted yellow line, each dot smaller than one scale; ocellated white spots on labials; those on posterior labials elongated blue-white dashes bordered below and above by black, more or less connecting with the narrow yellow line. Body brownish with an indistinct median row of tiny black dots and lighter points between; two median rows a little darker than adjoining scalerows;

edges of ventrals and subcaudals colored like first scalerow with a black dot near outer side of each; anterior ventrals with a median pair of black spots also.

Measurements in mm.: Total length, 712; snout to vent, 530; tail 182; width of head, 8.7; length of head, 15.5.

Variation: The coloration in young animals is more distinct, and the pattern more sharply delineated than in old ones. A figure of a young specimen, No. 3180 (Chiang Mai province) is given. It brings out the character of the striping in the posterior part of the body which is largely lost in old adult specimens. The head markings are much the same in these two, as well as in No. 36070 captured at Kaeng Pang Tao in northern Chiang Mai (figured).

FIG. 19. *Sibynophis collaris* (Gray). No. 3180, Young, Chiang Mai province, Oliver Gordon Young, Coll. Actual length (tail mutilated), snout to vent, 310 mm.

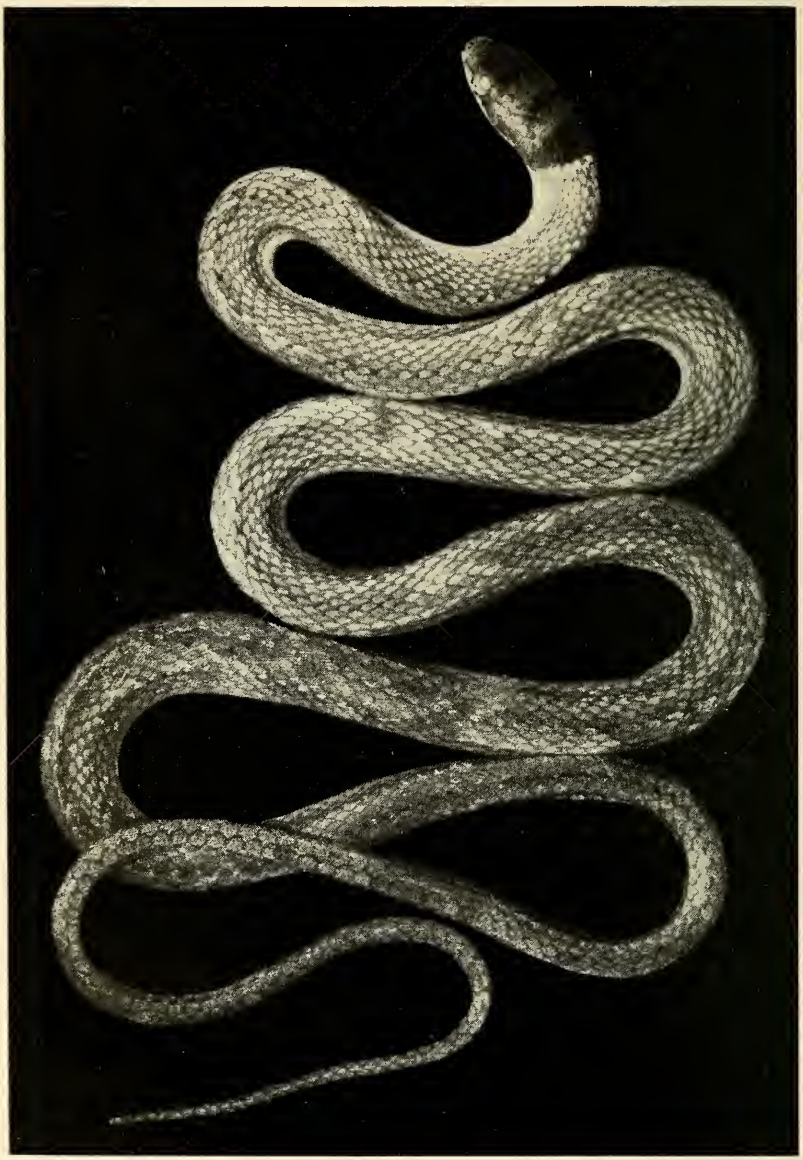

FIG. 20. *Sibynophis collaris* (Gray). No. 36070, Kaeng Pang Tao, northern Chiang Mai. Actual total length, 565 mm.

The known variation in ventrals (*fide* M. Smith) is 155 to 186.

Distribution: The specimens of this species that I have found or been able to study are all from Chiang Mai province. Dr. Malcolm Smith report the species from Koh Chang (island) in the Gulf of Siam.

Elsewhere *collaris* has been reported in northern India, Assam, Nepal, northern Burma and China.

Subfamily ACROCHORDINAE Jan

Acrochordidae Jan, Elenco syst. ofid., 1863, p. 106.

Acrochordinae Boulenger, Catalogue of the snakes in the British Museum, ed. 2, vol. 1, 1893, p. 172 (*part.*).

Hypapophyses present throughout vertebral column; postorbital bone semicircular, partly surrounding upper part of orbit; frontal with two anterior lateral processes; prefrontal small, vertically hanging from the end of frontal expansion, not extending forward upon snout. Skin loose with or without median ventral "seam" or fold.

While there is considerable reason for recognizing these snakes as a distinct family, they are here treated as a subfamily.

For many years two genera, *Chersydrus* and *Acrochordus* were recognized in this subfamily, the most significant difference between them being the presence of the median ventral "seam" or fold present in *Chersydrus.* M. Smith (1943) has united the two stating that, "The presence of a distinct median abdominal fold in *Chersydrus granulatus* does not seem sufficient to separate it generically from Acrochordus."

There are, however, certain other differences besides this (*e. g.* ear-bones). However, until further study of the skeletal characteristics demonstrate still greater differences, I shall accept the proposal of Smith and regard *Acrochordus* as the only genus in the subfamily, with *Chersydrus* a synonym.

Genus *Acrochordus* Hornstedt

Acrochordus Hornstedt, Vet. Acad. Hand., Stockholm, vol. 8, 1787, p. 307 (type of genus, *javanicus*).

Potomophis Schmidt, Abh. Naturv. Hamburg, vol. 2, 1852, p. 75 (type *javanicus;* name preoccupied).

Chersydrus Cuvier, Règne Animal, vol. 2, 1817, p. 75 (type, *fasciatus* Shaw = *granulatus* Schneider).

Diagnosis: Head not distinct from neck; body moderate to very stout, the skin loose, covered with small juxtaposed tubercles; no ventrals present; nostrils surrounded by circular scales; eyes dorsal,

small; pupil vertical; chin produced forward fitting into a depression in upper jaw. Maxillary teeth, 12-15, subequal; tail only feebly compressed, somewhat prehensile.

The distribution of this subfamily extends from India through southeastern Asia, the Indo-Australian Archipelago into Northern Australia. Two species are recognized, both occurring in Thailand. They are found in marine waters, river mouths, and even in fresh water. In Thailand the species *javanicus* is known as *ngu nguang chang*, the elephant-trunk snake. It is not uncommon in the canals of Bangkok.

KEY TO THE SPECIES OF ACROCHORDUS IN THAILAND

1. Nostrils terminal directed forward; from 130-150 scales about body, no distinct ventral median fold; no transverse bands; usually some longitudinal striping..... *javanicus*
   Nostrils dorsal, directed upward; approximately 100 scales about middle of body. A well-defined median ventral fold; a banded color pattern, *granulatus*

Acrochordus javanicus Hornstedt

Acrochordus javanicus Hornstedt, Abh. Acad., Stockholm, vol. 8, 1787, p. 307 (type-locality, Java); Schlegel, Abbildungen . . . Amphibia, 1839, pl. 17, figs. 12-14; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 905; Günther, The reptiles of British India, 1864, p. 336; Boulenger, Catalogue of the snakes in the British Museum, 2nd ed., vol. 1, 1893, p. 173; Flower, Proc. Zool. Soc. London, 1899, p. 658; Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914-1915, p. 13, 187, 212; de Rooij, The snakes of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 43, fig. 22; Smith, Bull. Raffles Mus., no. 3, 1930, p. 39; Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 132-134, fig. 43, a and b; Tweedie, The snakes of Malaya, 1954, p. 38.

Diagnosis: Large snakes reaching approximately two and one-half meters in length, the girth reaching above 300 mm.; snout blunt, nostrils directed forwards and upwards; eyes dorsal; tubercular scales small, 130-150 around middle of body; no ventral fold on body; no widened ventrals.

Description of species (from No. 1693, Bangkok): Front of snout covered with several curving rows of small irregular scales; nostrils surrounded by two ringlike scales touching mesially, directed straight forward; eyes small, separated from one another by 23 scalerows, from nasal by 14 scalerows; about 30 supralabials, separated from eye by ten scalerows; series adjoining supralabials a little larger than labials; about 31 infralabials; skin of lip itself thick and broken into more or less regular scalelike parts; median part of lower jaws forms a small forward projection that fits into a small arch in upper jaw. Scales on head smallest above eyes and in middle of occiput.

Posteriorly on tail scales rather flattened with a median keel and each side elevated into two blunt keels. These scales may be imbricate; anteriorly keels become higher and somewhat mucronate, the scales separated, tending to stand more erect; posterior edge of scale develops some small spinelike projections; finally scale stands erect the median keel now like a small cone with lateral mucrone-like projections forming smaller cones. The central part around cones covered with perhaps hundreds of fine hairlike projections visible under magnification.

On median ventral line a vague elevation; tubercles here smaller than elsewhere around body, those on chin and throat smallest of all. Scales around neck, 126; about middle of body, 126; just anterior to vent, 58. Approximately 566 transverse rows; the extruded hemipenes are approximately 110 mm. in length. Each bifurcates 38 mm. from end, the entire bifurcated parts covered with about 15 somewhat irregular rows of short hard spines. The groove divides and one branch reaches terminus of each bifurcation; proximal to the division there are smooth irregular folds.

Color in life: Above generally olive with a black median stripe with irregular borders; below the olive color a pale yellow stripe with poorly defined edges; below this is a black stripe broken at intervals, continuing back onto tail; below black stripe the sides and venter dull yellowish white, and about midway of body two or three series of dark spots of irregular shape and size begin and continue to vent; subcaudal region dull olive-brown without spots.

Measurements in mm.: Total length, 1725; tail, 301; snout to vent, 1424; width of head, 36; length of head, 55.

Variation: The number of supra- and infralabials vary between 25-32; the number of scales between the eyes varies between 18 and 24; and the number of scales around the body, between 130 and 150. The young are more clearly marked than the adults, and they may be spotted all over.

Distribution: Known from mouths of streams emptying into the Gulf of Siam, and in canals and fresh water klongs that are near stream mouths. It is not a rare snake in klongs and canals in Bangkok.

It is known from the coasts of Cambodia, Cochin China, Malay, the Indo-Australian Archipelago, and Queensland.

Remarks: These snakes are known to reach a length of 2304 mm. (*fide* Günther). They produce 25 to 32 living young at a time. The food consists largely or entirely of fish.

Acrochordus granulatus (Schneider)

(Fig. 21)

Hydrus granulatus Schneider, Historiae amphibiorum naturalis et literariae, vol. 1, 1799, p. 243 (type-locality, India).

Chersydrus granulatus: Günther, The fauna of British India, 1864, p. 336; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, Saigon, 1885, p. 39; Boulenger, The fauna of British India, Reptilia and Batrachia, 1890, p. 355, fig.; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 174; Flower, Proc. Zool. Soc. London, 1899, p. 658; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 116-117, fig. 38; Annandale, Journ. Asiat. Soc. Bengal, vol. 74, 1905, p. 175; Mem. Ind. Mus., vol. 5, 1915, p. 169; Wall, Journ. Bombay Nat. Hist. Soc., vol. 15, 1918, p. 756; The snakes of Ceylon, 1921, p. 79; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 167; Brongersma, Zool. Med. Rijks. Mus., vol. 16, 1933, p. 14; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 14; Bourret, Les serpents de l'Indochine, 1936, pp. 35-36, fig. 14.

Acrochordus fasciatus Shaw, General zoology, vol. 3, p. 576, pl. 130 (type-locality not stated).

Chersydrus annulatus Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 61 (type-locality, Singapore and Madras).

Acrochordus granulatus: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 906; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3 Serpentes, 1943, pp. 134-135; Tweedie, The snakes of Malaya, 1954, p. 38; Smith, Bull. Raffles Museum, no. 3, 1930, p. 39.

Diagnosis: Body whitish with a series of 50 or more black bands, widened on back, narrowed on sides and venter; no widened ventrals; a narrow median fold on venter; eye very small with a minute round pupil; nostrils on top of snout, directed upwards; tail somewhat compressed; large series of scales on upper and lower jaw separated from mouth by a series of much smaller scales. Scales tubercular or keeled; about 100 scales around middle of body.

Description of species (from No. 479, Songkhla): Rostral scale very narrow, doubly arched, concealed in a notch of upper jaw, not visible from above; twelve small scales border upper lip; bordering these scales above, a series of 12-13 larger (true) labials; between nostrils and the enlarged series there are two rows of scales, the lower ones enlarged; a single row of scales between nasals; nasals are narrow circular rims about circular craters, followed behind by at least one enlarged scale; eye small with a minute circular pupil, surrounded by eleven small scales varying in size; approximately twelve scales in a line between eyes; a series of about twelve small scales separating a series of much larger infralabial scales from lip; mental in notch between lower jaws, median part of lower jaw fitting into a median notch in upper jaw; scales on snout behind nostrils larger than those on occiput.

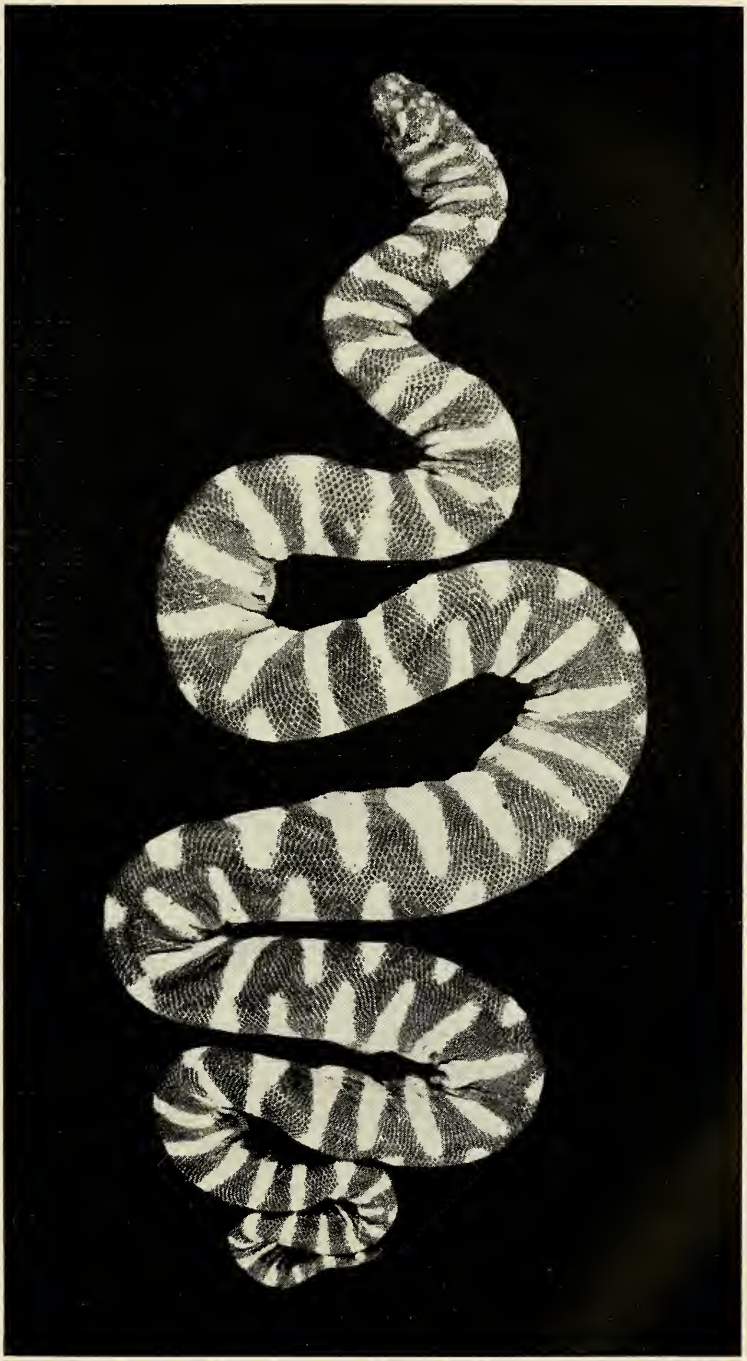

FIG. 21. *Acrochordus granulatus* (Schneider). No. 479, Songkhla, Songkhla province, southern Thailand. Actual total length, 649 mm.; tail, 69 mm.

Scalerows about body: 62, 77, 93, 83, 48, largest scales on dorsum, each with a keel or tubercle; scales along median part of venter pointed; most scales at least anteriorly on body, are elevated, with a short spine arising near to a terminal pit.

Maxillary teeth, 16, for the most part subequal, smallest posteriorly; 15 mandibular teeth decreasing posteriorly.

Color in life: Head blackish with a few dirty white spots; neck and body dirty whitish encircled by approximately 52 black bands, widest on middorsal line, narrowing on the sides and venter, often anastomosing on back, tending to form a median zigzag stripe for a distance. Tail with 13 bands.

Measurements in mm.: Total length, 649; tail, 69; head-width, 14; head-length, 16.5.

Variation: The markings become indistinct in old specimens. The scales in a row between the eyes vary from seven to ten. The scales around the middle of body vary between 89 and 100.

Distribution: In Thailand the species is not uncommon along the coasts. Specimens are more frequently taken near mouths of rivers emptying into the Gulf of Siam. Outside of Thailand the species is known in India, Ceylon, Indo-China, Malaya and the Indo-Australian Archipelago as far as Australia and the Philippines. In the latter country the species occurs very commonly in the large fresh-water lake Laguna de Bay, on the Island of Luzon.

Remarks: This serpent seemingly pays no attention to the presence of man. They are quiet and inoffensive. I have never seen one attempt to bite.

Subfamily COLUBRINAE Cope

KEY TO THAI GENERA OF THE COLUBRINAE

1. Fanglike anterior maxillary teeth 2
   No fanglike anterior maxillary teeth 3
2. Maxillary bone strongly arched; rather small snakes (usually under one meter in length) ..... *Lycodon*
   Maxillary bone not strongly arched; larger, (to one and one-half meters, *Dinodon*
3. Maxillary teeth increasing in size from front to back 4
   Maxillary teeth subequal or anterior teeth slightly larger 6
4. Pupil vertically elliptic; six to ten teeth on maxillary; scales in 13 rows around body; slender banded arboreal snakes ..... *Dryocalamus*
   Pupil round 5
5. Maxillary teeth 20 to 28 (Thai species), forming a continuous series, *Ptyas*
   Maxillary teeth 6 to 16, the posterior ones strongly enlarged and compressed; rostral large, often elevated extending well on upper surface of the snout ..... *Oligodon*

6. No temporal scales 7
   Temporal scales present 9
7. Ten to twelve maxillary teeth; very small snakes (250 mm.); internasals present; scales in 15 rows ..... *Pseudorhabdion*
   Eight to eleven maxillary teeth, small snakes, less than half a meter in length; no separate internasals (fused with prefrontals); scales in 13 rows, *Calamaria*
9. Scales in 19 or more rows 10
   Scales in 13 or 15 rows 11
10. Scalerows, 23-25; snout projecting; anterior maxillary teeth somewhat larger than others; an elongate loreal three to four times as long as high; large (2 meters) ..... *Gonyosoma*
    Scalerows, 19-23; maxillary teeth subequal, sometimes anterior, sometimes posterior a little the larger; loreal not twice as long as high; terrestrial snakes, 1½ to 2 meters; longitudinal or banded markings; *Elaphe*
11. Elongate slender arboreal species; scales variable in shape; transverse rows strongly oblique; pupil round; about one meter in length; *Ahaetulla*
    Shorter terrestrial species, the scales nearly uniform; pupil round or vertically elliptic 12
12. Pupil vertically elliptic; 16-20 equal maxillary teeth; anterior temporal not longer than posterior; loreal not especially small; (less than half a meter in length) ..... *Plagiopholis*
    Pupil round; 26-28 maxillary teeth, subequal; anterior temporal twice length of posterior; loreal very small; (to half a meter in length); *Liopeltis*

Genus *Gonyosoma* Wagler

Gonyosoma Wagler, Natürliches System der Amphibien, 1828, pl. 9 (type of genus, *viridis* = *oxycephalum*); Taylor, Snakes of the Philippine Islands, 1922, p. 152.

Diagnosis: A genus of large arboreal snakes reaching a length of 2.3 meters; scales faintly keeled or smooth; elongate apical pits present; loreal elongate; hemipenes with spines elongated.

There is no unanimity of opinion as to the number of species in this genus, but two forms, possibly three are known to occur in Thailand. It is probable that *floweri* and *jansenii* should be placed in the genus *Elaphe.*

KEY TO FORMS OF *Gonyosoma* IN THAILAND

1. Uniform green on body, (the interstitial skin with black and white reticulations); ventrals outside lateral keel whitish; tail often colored differently from body, usually reddish or each caudal scale edged with darker; two supralabials border orbit ..... *oxycephalum*
   Not uniform green 2
2. Light or dark buff marked all over by scattered irregular blotches of dark brown or black; venter uniform whitish or with spots similar to those on dorsum; two supralabials enter eye, third touches it at a point ..... *floweri*
   Bright yellow-brown above, the scales black edged. A pair of black lateral stripes begin at about the 36th ventral level, and continue back, widening greatly. Venter yellowish anteriorly, blackish with yellow keels posteriorly; three labials border orbit ..... *jansenii elegans*

Floweri is known from Singapore north to Trang province in Thailand. *Jansenii elegans* is known from the type taken reputedly in Thailand by (Schilling). *Jansenii* is a Celebean species, and the presence of this form in Thailand should be reconfirmed.

Gonyosoma floweri (Werner)

Coluber floweri Werner, Stizb. Akad. Wiss. Wien, Abt. 1, vol. 134, p. 55 (type-locality, Singapore).

Elaphe oxycephala (*part.*) M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes 1943, pp. 144-146).

Diagnosis: See key.

Description of species (from type-description): Internasals three fifths as long as prefrontals; frontal one and one-third times as long as broad, as long as its distance from rostral, shorter than parietals; loreal three times as long as broad (left one split vertically); a large preocular in contact with frontal; two postoculars, upper distinctly larger than lower. Temporals, (left), $2 + 2 + 3$; (right), $3 + 2 + 3 + 2 + 1$; ten supralabials, sixth to eighth border orbit; five to seven infralabials in contact with anterior chinshields. Eye not half as long as its distance from nostril.

Color: Above bright yellow-brown, scales black-edged with small irregular black flecks. A dark postocular band above upper edge of supralabials; venter yellowish; tail spotted.

Measurements: About one and one-half to two meters.

Remarks: This snake is related to *Gonyosoma j. jansenii* Bleeker of Celebes.

The three supralabials, sixth to eighth (fifth to seventh) borders orbit. The postorbital band is present and this and the distinctive coloration of the posterior part of the body seems to separate *floweri* from the species in Celebes.

Gonyosoma jansenii Bleeker

Gonyosoma jansenii Bleeker, Nat. Tijdschr Nederland Ind., vol. 16, 1858; (type-locality, Manado, Celebes); Boulenger, Proc. Zool. Soc. London, 1897, p. 220.

Allophis nigricaudus Peters, Monatsb. Akad. Wiss. Berlin, 1872, p. 686.

Elaphis nigricaudus: Peters and Doria, Ann. Mus. Civ. Genova, vol. 13, 1878, p. 387.

Diagnosis: See key.

This form presumably has two subspecies the typical form in Celebes and a second one described from Siam by Werner as *Coluber jansenii elegans.* He however regarded it as a "Färben-

varietät." There may be some doubt that the form actually originated in Thailand. (The collector's name is given as "Shilling".)

Gonyosoma jansenii elegans Werner

Coluber janseni elegans Werner, Sitzungsb. Akad. Wiss. Wien, Abt. 1, vol. 134, 1925, pp. 55-56 (type-locality, "Siam").

Elaphe oxycephala M. Smith, The fauna of British India, Ceylon and Burma . . . vol. 3, Serpentes, 1943, pp. 144-146 (*part.*).

Description (from type-description of ♂): Ventrals, 257, subcaudals, 132 + 1; scalerows, 25. Loreal twice as long as high; nine supralabials, fifth to seventh border eye, ninth very long. Temporals, 2 + 3 + 4.

Color: Bright yellow-brown; lateral stripes begin on sides above the 3rd ventral; at first two small short lines that fuse and widen, covering about eight scalerows posteriorly. The edges of stripe irregular at first then they become parallel, the five scalerows between being lighter; posterior part of body and tail entirely black. Anterior part of venter uniform yellow, posteriorly bordered with black.

Measurements: Not recorded ("groses" ♂).

Gonyosoma oxycephalum (Boie *in* Boie)

Coluber oxycephalus Boie *in* Boie, Isis, 1827, p. 537 (type-locality, Java); Boulenger, The fauna of British India, including Ceylon and Burma; . . . Reptilia and Batrachia, 1890, p. 335; Catalogue of the snakes in the British Museum, 2nd ed., vol. 2, 1894, p. 56; Annandale, Journ. Asiat. Soc. Bengal, vol. 1, 1905, p. 175; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1901; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 143-144; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 622; M. Smith, Proc. Zool. Soc. London, 1921, p. 426; Rendahl, Ark.-Zool. Sven. Vet., vol. 29, A. 10, 1937, p. 22.

Herpetodryas oxycephalus: Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 189, pl. VII, figs. 8, 9; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 927.

Gonyosoma oxycephalum: Günther, The reptiles of British India, 1864, p. 294. Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 193. Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 51, 65; Taylor, Snakes of the Philippine Islands, Bureau of Sci. Manila Publ. 16, 1922, pp. 152-155; Schmidt, Amer. Mus. Novitates, no. 157, 1925, pp. 1-5; Dowling, Copeia, 1958, no. 1, pp. 29-40, fig. 1A.

Elaphe oxycephala: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, Mar. 1915, p. 213; *ibid.*, vol. 2, No. 2, Dec. 1916, p. 161; Proc. Zool. Soc. London, 1921, p. 426; Journ. Federated Malay States, vol. 10, 1922, p. 266. Bull. Raffles Mus., no. 3, 1930, p. 50; Bourret, Les serpents de l'Indochine, 1936, vol. 2, pp. 204-206, fig. 81; M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 144-146, fig. 45.

Gonyosoma viride Wagler, Descriptiones et icones amphibiorum pt. 1, 1828, pl. 9 (type-locality "Brazil").

Alopecophis chalybeus Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 4, p. 247 (type-locality "Mauritius").

Aepidea robusta Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 488 (type-locality, Gasper Straits, Malay Archipelago); Stejneger, Proc. United States Nat. Mus., vol. 69, 1926, p. 3 (= *oxycephalum*).

Diagnosis: Large snake exceeding two meters in length; snout about three times as long as eye; supralabials, 10 to 11, last much enlarged; 12 to 14 infralabials; ventrals somewhat keeled; scale-formula: 23, 23, 15; entire head and body green in life; tail brown-buff or reddish; light yellow-green below.

Description of species (from No. 33638, Doi Suthep, Chiang Mai, Gordon Young, Coll.): Snout three times length of eye, somewhat wedge-shaped extending noticeable beyond mouth; rostral higher than wide; visible above as a small triangle; internasal longer than wide; prefrontals longer than wide, touching loreal and posterior nasal laterally; frontal small, rounded posteriorly front edge nearly straight anteriorly, less than a fifth longer than wide, shorter than its distance to end of snout; shorter than parietals; nasal completely or partially divided, anterior part as large as posterior; loreal about three times as long as high; preocular large, about as long as high, bordering frontal; supraoculars three fifths as wide as frontal; two postoculars; temporals somewhat irregular; nine supralabials, three touching loreal, sixth and seventh entering orbit; last double the length of two preceding it; infralabials, 12, six touching large chinshields which are more than four times size of second pair.

Scale-formula: 30, at first ventral, 23 (24), 24 (25), 16, (15). The scales with indistinct paired apical pits; several dorsal scale-rows very near middle of body showing almost obsolete keels. Each scale shows longitudinal striation under magnification.

Maxillary teeth 21-21; anterior a little longer and more curved than posterior.

Color in life: Body green above, darkest on head; tail light chestnut or buff-red, the two colors meeting abruptly at level of vent. On anterior half of body scales may be edged with black; an indistinct blackish stripe along side of head immediately above labials; light greenish-yellow below on venter.

The specimen here described is darkened by preservation and is nearly uniform plumbeous; venter dark, the posterior edge of each ventral scale being whitish; a whitish line following blunt keel along each side of ventrals. A light area on rostral and a light area on each side under head. The chinshields and infralabials plumbeous; a slightly wider light line follows keel on subcaudals; tail brownish, the scales with a somewhat lighter center.

Measurements in mm.: Snout-vent, 447; tail, 142; total length, 589; length of head, 20; width of head, 12.

Variation: A specimen captured at Khao Chong (No. 35708) differs somewhat from that described. The rostral is visible above as a narrow line; the internasal is small, less than half the area of a prefrontal. The frontal is pentagonal and rounded somewhat posteriorly. Two (or three) preoculars, the one (or two) lower scales separate the fifth labial from eye. The temporal formula is 1 + 2 +3. Ten supralabials are present, the sixth and seventh bordering eye, and thirteen infralabials. The second pair of chinshields are separated by two or three scales.

The coloration in life of this specimen was as follows:

The body was green with a buff or reddish tail, and a greenish yellow venter. Many of the scales on the anterior part of the body were decorated with a tiny line of blackish dashes, while farther back many of the diagonal transverse scalerows had each scale bearing tiny white dashes. On the sides the black and white marks were concealed normally by imbricating scales. The top of the head and chin were green while the throat was yellowish white. The tail was reddish but each scale had a darker border. A median dark zig-zag line flanked by unpigmented reddish stripes, was on under side of the tail.

This specimen has the following scale-counts: scale-formula 32 (occiput), 27, 25, 25, 17. The ventrals are 249, keeled and often notched; subcaudals, 138; anal, divided.

Distribution in Thailand: The species has been taken in the provinces of Chiang Mai, Narathiwat, and Trang.

Outside of Thailand the species is known in Cambodia, Malaya, Singapore, Burma, Borneo, Java, and the Philippines.

Remarks: The species is very large reaching a known length of 1880 for a male; 2100 mm. for a female.

Genus Elaphe Fitzinger *in* Wagler

Elaphe Fitzinger, *in* Wagler, Descriptiones et icones amphibiorum, pt. 3, 1833, text to pl. p. 27 (type of genus *parreysi* = *quatuorlineatus*).

Diagnosis: Maxillary teeth, 14-24 somewhat enlarged anteriorly and posteriorly; head only slightly distinct from neck; pupil round; body subcylindrical; scales with paired apical pits in 19 to 27 rows, smooth or keeled; ventrals rounded or angulate laterally; subcaudals divided; five or six infralabials touch first chinshields.

A very large genus with species in Asia, Europe, and North America. In Thailand four species are known, all of them having wide ranges.

They may be differentiated by the following key:

KEY TO THAI SPECIES OF *Elaphe*

1. Scales in 19 (more rarely 21) rows 3
   Scales in more than 21 rows 2
2. Scales in 23 rows; a black stripe along side of head; anterior part of body nearly unicolor; posteriorly with a median light stripe and two broad black stripes ..... *taeniura ridleyi*
   Scales in 23 to 25 rows; anterior part of body with a median series of butterfly-shaped spots and a lateral series of smaller diamond-shaped spots, *taeniura taeniura*
3. A single narrow black transverse occipital bar or band with black lines running forward from bar to eye; head coppery brown ..... *radiata*
   Numerous wide dark transverse bars on body or none 4
4. Scales smooth; body reddish brown with numerous wide dark-edged dark-brown crossbands; a pair of black lines running forward from first band to eyes; a median black stripe on head ..... *porphyracea porphyracea*
   Scales keeled; a median light yellowish-brown stripe flanked by two narrow black stripes anteriorly; a series of black ventrolateral spots or ocelli on anterior third of body ..... *flavolineata*

Elaphe taeniura (Cope)

Elaphis taeniurus Cope, Proc. Acad. Nat. Sci., Philadelphia, 1861, vol. 12, p. 565 (type-locality, Ningpo and Siam); M. Smith, The fauna of British India . . . vol. 3, Serpentes, 1943, pp. 150-152.

Thailand has two forms, presumed subspecies of *taeniura.* One, *t. ridleyi,* is a common inhabitant of certain caves in peninsular Thailand; the other a northern form, reported by Malcolm Smith, from Chiang Mai and Hin Lap in the Dong Rek mountains, presumably belongs to the typical subspecies.

KEY TO THAI SUBSPECIES OF *Elaphe taeniura*

1. Top of head dark gray; side of head with a black stripe from angle of jaw, fading near nasal. Anterior part of body pale flesh gradually developing pigment forming two broad black bands with a median cream band between and bordered by yellow stripes on outer scalerow and outer part of ventrals; this yellow line bordered by faint dark lines to tip of tail, *t. ridleyi*
2. Similar head marks but anterior part of back with a vertebral series of butterfly-shaped black spots and smaller diamond-shaped ones on sides; posterior part of body similar ..... *t. taeniura*

Elaphe taeniura ridleyi (Butler)

(Fig. 22)

Coluber taeniurus var. *ridleyi* Butler, Journ. Bombay, Nat. Hist. vol. 12, 1899, p. 426 (type-locality, Batu Caves, Kuala Lumpur, Malaya); Ridley, The Times, Nov. 10, 1937.

Coluber taeniurus: Boulenger, Fasciculi Malayenses, vol. 1, zool. 1, 1903, pp. 162-163 ("Goah Tanah, near Biserat, Jalor").

Coluber taeniurus pallidus: Rendahl, Ark. Zool. Stockholm, vol. 29, (A), 10, 1937, p. 19 (type-locality, Sukli, Tenasserim, Burma).

Elaphe taeniurus grabowskyi: (*part.*) M. Smith, Bull. Raffles Mus., Sinagpore, Straits Settlements, no. 3, Apr. 1930, pp. 49-50.

Elaphe taeniura: Smith, (*part.*), The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese subregion; Reptilia and Amphibia, vol. 3, Serpentes. Dec. 1943, pp. 150-152.

Diagnosis: Anterior maxillary teeth larger than posterior. Head dull slate above with a black stripe through loreal region to jaw-angle; supralabials and infralabials generally yellowish. Anterior half of body light fawn, the neck region only a shade darker; near middle of body, dorsum and sides, except outer scalerow and adjoining half-row, with more dark pigment, continuing to grow from grayish slate to black except for a broad yellowish median line.

Description of subspecies (from No. 665 from Khao Kampan, Yala province, Thailand): Rostral wider than high not or scarcely visible from above; internasals tending to bend down slightly anteriorly, equal in size to about one half area of prefrontals which have a common suture nearly the length of the scales; frontal (9 mm. x 11 mm.) shorter than its distance from tip of snout, shorter than its distance to end of parietal; two nasals, subequal in size; loreal elongate, one-and-a-half times as long as high; two preoculars, lower small (subocular), upper large forming a suture with frontal; supraoculars subtriangular; parietals bordered by three temporals; two postoculars; temporals, two anterior, arranged $\frac{1+2}{1}+3$ (4); supralabials, 9-9, three touching loreal, fifth and sixth bordering orbit; infralabials, 11-12, six touching first chin-shields which are a little wider but about same length as second pair.

Scale-formula: 32 (occiput), 29, 27, 19. Scales smooth on anterior part of body, becoming weakly then strongly keeled except on two or three outer rows which remain smooth throughout. Scales with paired apical pits. Body compressed posteriorly; venter with lateral keels; outer edge of ventrals turned upwards on side; keels not in evidence on neck and tail. Ventrals, 295; subcaudals, 114; anals, 2.

Color in life: Head dull slate above with a black stripe through loreal region and back of eye to jaw-angle; supralabials yellow except for first two or three, and upper edges of certain others; infralabials entirely yellowish; anterior half of dorsum yellowish fawn except outer part of ventrals; near middle of body pigment becomes evident, at first light lavender, then becoming darker lavender,

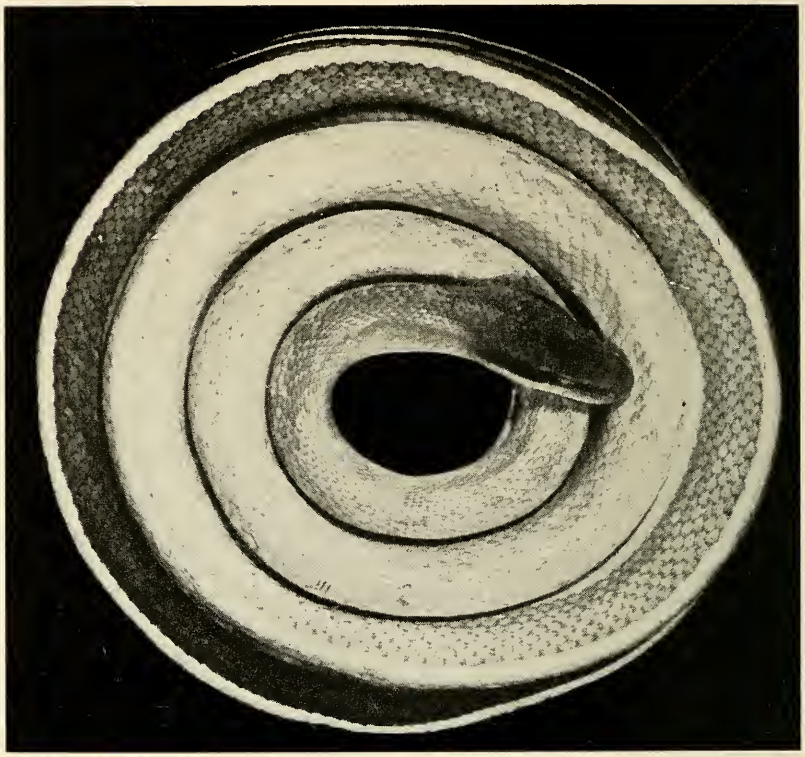

FIG. 22. *Elaphe taeniura ridleyi* (Butler). EHT-HMS No. 1627, Khao Kampan (Mt.) cave, Yala province, southern Thailand. Actual total length, 1852 mm.; tail, 370 mm.

purplish slate, and finally black towards end of tail; about midway, scalerow bordering lateral part of ventrals and half of adjoining scalerow develops a bright yellow stripe which includes outer edges of ventrals; below this a dorsoventral dark line on upturned part of ventrals continues to end of tail on outer part of subcaudals; a median yellow stripe begins on dorsum at about the middle of body and grows more intense, covering one whole and two half rows of scales, extending to tip of tail; venter yellowish; underside of chin ivory.

Measurements in mm. (No. 665 and an unnumbered specimen in the Boonsong Lekagul collection, both from same cave): Snout to vent, 1475, 1492; tail, 365, 390; total length, 1840, 1882; diameter of eye, 6, 7; eye to end of snout, 15, 15; width of head, 26.5, 32.6; length of head, 46.5, 50.

Variation: The second specimen has 286½ ventrals, 114 subcaudals; divided anal; supralabials, 9-9; infralabials, 11-12, five or six touching first chinshields. The color is nearly identical with that of the described specimen. Other head-scales are practically the same, except the temporals have a slightly different arrangement.

The variation in ventral and subcaudal counts is from 276 to 305; 89 to 112. The scalerows about the middle of the body are 25. While three supralabials normally border the orbit, the fourth may be separated only by a small subocular scale.

This form is usually very pale. Those found in the open are somewhat darker but presumably the normal habitat for this subspecies is in caves. All cave specimens I have seen are extremely uniform in color and markings.

Distribution: The pale *ridleyi* is known in Thailand in the southern part of the peninsular area. Specimens have been taken only from caves in Yala province.

The subspecies is also known from the limestone caves of northern Malaya, and it may be presumed that Rendahl's *taeniura pallidus* from Sukli, Tenasserim belongs here.

The Bornean form of *taeniura* has different anterior coloration and markings; also fewer ventrals and subcaudals than the peninsular form. This subspecies has been named *t. grabowskyi.*

Remarks: The specimen described is from a cave in Khao Kampan in this district of Yala. The first record is that of Boulenger from "Goali Tanali, near Biserat, Jalor." This place name seemingly is unknown to the area at the present time. The entire political geography has changed. The seven Pattani States have been divided into the present Changwats of Narathiwat, Pattani, Yala and Songkhla and it is not possible to state with certainty whether Jalor is wholly within the present province of Pattani or not.

I visited the Khao Kampan cave with Nai Prayoon Kananuracks. We obtained three specimens of this species. While here we came upon a *Dendrasphis hannah* (the king cobra) at a distance of more than 350 meters back from the mouth of the cave. I captured the specimen alive with some difficulty. It was presumed that the cobra was seeking the elaphid snakes for food.

Elaphe taeniura taeniura (Cope)

Elaphis taeniurus Cope, Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 565 (type-locality, Ningpo and Siam).

Coluber taeniurus: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 333; Catalogue of the snakes in the British Museum, vol. 2, 1894, p. 47.

Elaphe taeniura: Pope, The Reptiles of China, 1935, pp. 271-277, fig. 58; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3; Serpentes, 1943 pp. 150-152 (*part.*).

Diagnosis: Anterior maxillary teeth largest; light brown above uniform on head and neck, except for a black stripe on each side of head, broadest behind eye; anterior part of back with a vertebral series of large black butterfly-shaped spots and smaller diamond-shaped spots on sides which tend to break up with age; posterior part of back with a gray vertebral stripe bordered by a broad black stripe on each side.

Description of species (type description): "Head slightly distinct, lanceolate, muzzle obtuse. Tail one-fifth the total length, flat beneath. Twenty-five rows of scales, those from the ninth to the sixteenth keeled. Rostral plate broader than high, the labial suture one-third the nasal, less than the prefrontal. Eight superior labials, fourth and fifth bounding the orbit. Seventh much longer than high, bounded above by a long temporal, and by a short one, which also bounds the eighth labial. Postoculars two, superior largest. Preoculars two, as in other species of the genus, the superior very large, its horizontal diameter greater than the length of the loreal. The latter plate much longer than high. Postfrontals large, bent upon the sides. Anterior border of the vertical [frontal] shorter than the straight convergent lateral; posterior angle obtuse. Superciliaries large. Occipitals [parietals] elongate, external borders convergent, bounded by two long temporals. Inferior labials ten, eleven, or twelve. Gastrosteges [ventrals] 232; one divided anal; urosteges [subcaudals] 101 pairs. Total length of specimen from Ningpo 64 in., tail 13 in.; specimen from Siam 30 in., tail 6 in., 3 lines."

Color: "Above, an olivaceous ash, or clay color, more olive anteriorly. A blackish lateral band extends from the tip of the tail, throughout the posterior third of the body, where it extends from the second to the ninth rows of scales, reducing the ground color to a dorsal stripe of three or four scales in width. It is divided by a number of irregular narrow vertical lines, at regular distances. The superior border is prolonged upon the anterior two-thirds of the body as an irregular, narrow, longitudinal black band, connected with that of the opposite side by similar short transverse bands at

distances of four or five scales. Irregular black borders and centers of the median lateral scales, are the only indications of the inferior part of the lateral band anteriorly. Gastrosteges tipped with black anteriorly; the central parts become gradually darker posteriorly, but finally give place to a yellow median band which extends to the tip of the tail. This is bounded by a blackish band on each side, which is separated from that of the sides by another yellow one, which involves the tips of the gastrosteges, and first row of scales. The only marking upon the head is a black postocular vitta, which extends along the upper borders of the labials and no farther, parallel to the commissure of the mouth. Pectus, throat, chin, and superior labials yellowish."

Measurements in mm.: Total length of largest known female specimen, 1980 mm.; tail, 340.

Distribution: The typical form is known in Thailand from Chiang Mai province, and the Dong Rek mountains of central Thailand. Elsewhere it is known from Sikkim, Burma, Hong Kong and northern Indochina. It is probable that this typical form extends further south than my records show.

Variation: The loreal may be twice as long as high; and of the seven to nine supralabials, two or three (rarely one) bordering the orbit. A presubocular is usually present. The scalerow-formula is usually, 23, 23, 19. In northern Indochinese territory this may be, 25, 25, 19.

Elaphe radiata (Schlegel)

(Fig. 23)

Coluber radiatus Schlegel, Essai sur la physionomie des reptiles vol. 2, 1837, p. 135, pl. 5, figs. 5-6; (type-locality, Java); Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 333-334; Catalogue of the snakes in the British Museum, vol. 2, 1894, pp. 61-62; Wall, Journ. Bombay Nat. Hist. Soc., vol. 19, 1910, p. 825; *ibid.*, vol. 23, 1914, p. 206, fig.; *ibid.*, vol. 29, 1923, p. 621; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, 1914, p. 95, pl.—.

Caelognathus radiatus: Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 6.

Elaphe radiata: Pope, The reptiles of China, 1935, pp. 261-263, fig. 56; Bourret, Les serpents de l'Indochine, 1936, vol. 2, p. 211; Shaw, Shebbeare and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 14, 1939, p. 73; M. Smith, The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia; vol. 3, Serpentes; Dec. 1943, pp. 146-148, fig. 46.

Coluber quadrifasciata Cantor, Proc. Zool. Soc. London, 1839, p. 51, (type-locality, Assam).

Tropidonotus quinquefasciata Cantor, *ibid.*, 1839, p. 54 (type-locality, Mergui, Tenasserim, Burma).

Diagnosis: Large snakes reaching a length of two meters; a transverse black occipital bar making a median angle; scales in 19 rows at midbody; last labial below eye touching temporals; scales keeled; snout twice as long as eye; loreal longer than high; a median yellow or yellow-brown line bordered by a black stripe on each side.

Description of species (from No. 33630, Nakhon Ratchasima province near Mauk Lek (Sara Buri province): Rostral about twice as wide as high, well visible above, posterior border convex; internasals about as wide as long, the median common suture less than half as long as that between perfrontals; latter a little longer than wide; frontal longer than wide, slightly shorter than its distance from tip of snout; shorter than parietals; nostril between two nasals, posterior a little the larger; loreal longer than high; preocular reaches top of head but fails to form a suture with frontal; two postoculars, upper touching parietal; temporals, 2 + 2 + 3, the two anterior touching sixth labial; nine supralabials, fourth, fifth, and sixth bordering eye, eighth largest; mental small; ten infralabials, first five bordering first chinshields which are wider, but shorter than second pair.

Scalerows: 21 on neck; 19 at mid-body, 17, before vent; anterior scales smooth; then at first, five median rows, posteriorly seven or nine rows, lightly keeled; scales with paired apical "pits." Ventrals, 242; anal, single; subcaudals, 94. On sides a series of elongated black spots along third and fourth scalerows and a narrower series along outer scalerow and edge of ventrals; more posteriorly the upper row forms a continuous line.

Color in life: Top of head olive becoming brown on temples and neck (top and side). A black transverse occipital bar connecting with eye by two black lines running forward; laterally bar reaching to level of ventrals and continued back as a narrow zig-zag black line for a short distance; a line below eye crossing supra- and infralabials; a diagonal black line from eye across back of mouth; a median clay-colored stripe, nearly three scales wide begins on occiput or near it, and runs back two thirds length of body; after a short distance this stripe, flanked by two broad black stripes varying from two to three or four scales wide at intervals, gradually narrows posteriorly, becoming brown about middle of body and is finally lost in the ground color; posterior part of body nearly uniform brown, median part slightly lighter; tail light brown, unicolor on top and sides; chin and ventral surface of neck dirty ivory for about

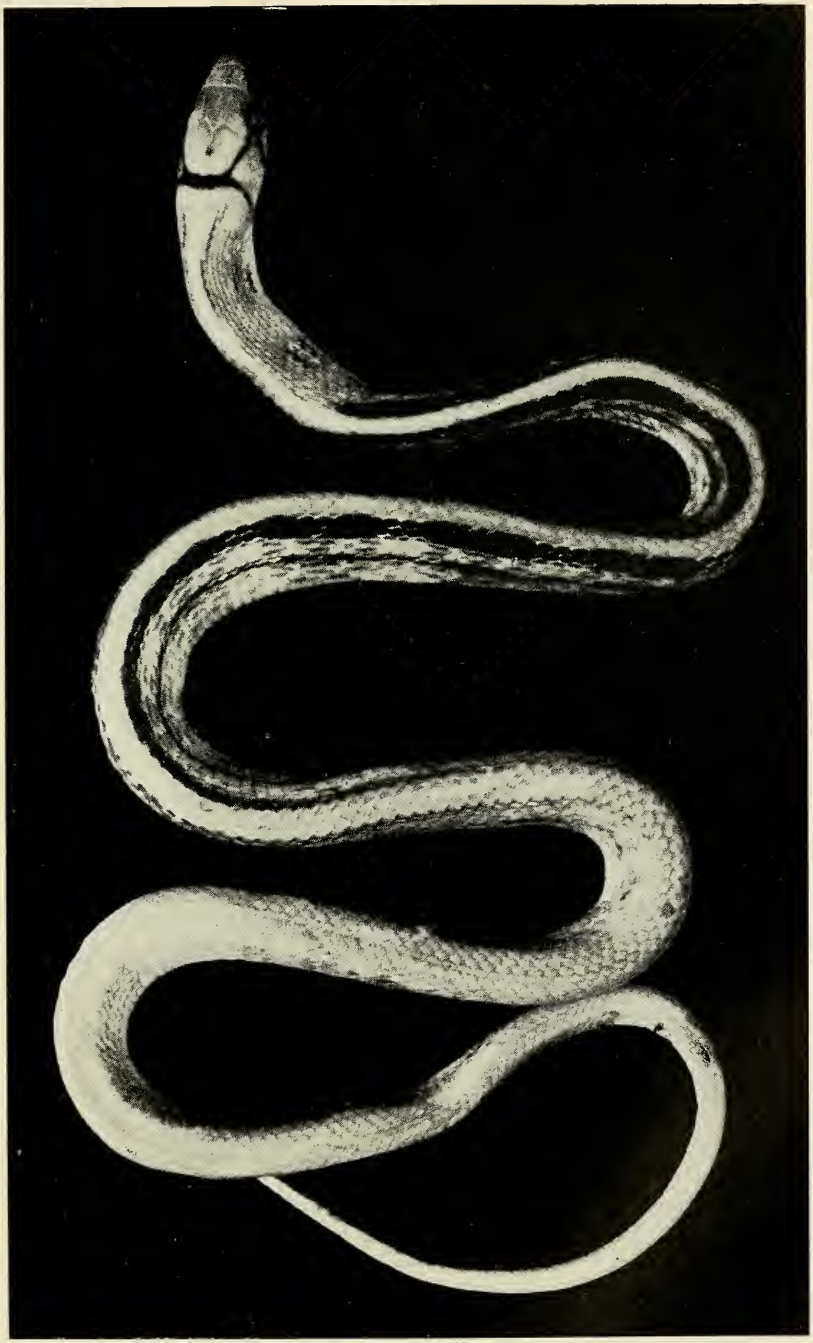

FIG. 23. *Elaphe radiata* (Schlegel). No. 404 ♀, Ratapoom, Songkhla province, southern Thailand. Actual total length, 542 mm.; tail, 99 mm.

16 centimeters; ventrals then begin to acquire gray pigment which becomes denser but lightens again near tail; subcaudal area uniform yellow-cream.

Measurements in mm.: Total length, 1440; snout to vent, 1163; tail 277; width of head, 20; length of head, 30.

Variation: Ventrals vary between 222 and 250, the subcaudals from 82 to 108. Rarely there are eight supralabials and occasionally there are but 19 scalerows around neck.

There is some variation in the coloration. Occasionally the body may have a reddish cast, but the pattern of the markings is relatively constant.

Distribution: The species occurs throughout Thailand in the lowlands, specimens having been taken in almost all areas where collections have been made.

Outside Thailand the species ranges from Orissa and Sikkim in India—east and south to southern China, Indo-China, Malaya and the Indo-Australian Archipelago.

Remarks: It feeds largely on small mammals frequenting the rice field. The juvenile figured is No. 404 from Ratapoom, Songkhla.

Elaphe porphyracea (Cantor)

Coluber porphyraceus Cantor, Proc. Zool. Soc. London, 1839, p. 51 (type-locality, Mishmi Hills, "Asam" Abor country).

Two subspecies are recognized, the typical one entering our territory in the northwestern part.

Elaphe porphyracea porphyracea (Cantor)

(Fig. 24)

Coluber prophyraceus Cantor, Proc. Zool. Soc. London, 1839, p. 51 (type-locality, Mishmi Hills, Assam, Abor country); Günther, The reptiles of British India, 1864, p. 239, pl. 20, fig. J; Boulenger, Catalogue of the snakes in the British Museum, vol. 2, 1894, p. 34; Annadale, Journ. Asiat. Soc. Bengal, 1905, p. 175; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 326; *ibid.*, vol. 19, 1909-1910, pp. 345, 827; *ibid.*, vol. 29, 1923, p. 620; *ibid.*, vol. 30, 1925, p. 812; Rendahl, Ark. Zool. K. Sven. Vet. Akad. Stockholm, vol. 29, A, 1937, p. 16.

Ablabes prophyraceus: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 308; Sclater, List of the snakes in the Indian Mus., 1891, p. 19; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1901, p. 611; Venning, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910, p. 337; Annandale, Rec. Ind. Mus., 1911, p. 217; *ibid.*, 1912, pp. 37, 47, 53.

Elaphe porphyracea: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 48; Pope, The reptiles of China, 1935, pp. 253-257, fig. 55; Bourret, Les serpents de l'Indo-Chine, 1936, p. 187; Shaw, Shebbeare, and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 14, 1939, p. 72; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 154-156, fig. 47.

Elaphe porphyracea prophyracea: M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 480.

Coronella callicephalus Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 390 (type-locality, Khasi Hills).

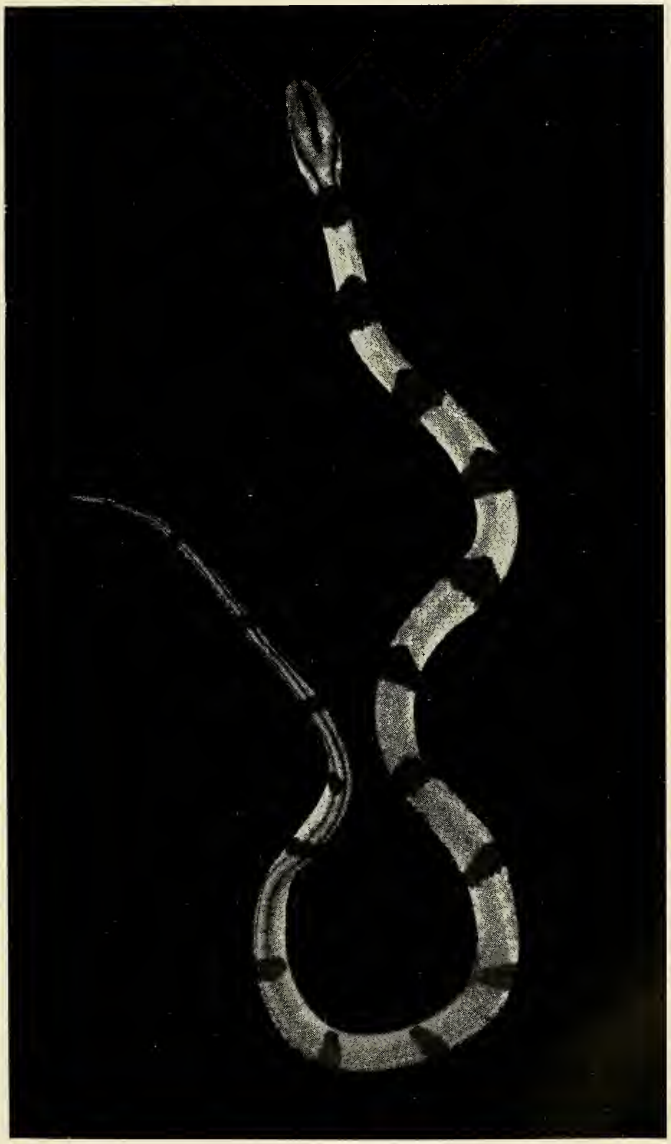

FIG. 24. *Elaphe porphyracea porphyracea* (Cantor). No. 36526, Doi Suthep, near Chiang Mai, Chiang Mai province, northern Thailand. Actual total length, 307 mm.; tail, 51 mm.

Diagnosis: Somewhat exceeding a meter in length (1100 mm.); scales smooth in 19 rows; loreal present; above reddish to magenta with a series of about 14 to 16 darker bands on body; two lines from first band extended forward along sides of head to eye; a median stripe on head; two dorsolateral black lines on posterior third of body and tail, a total of four darker bands indicated on tail.

Description of species (from No. 20926, Mae Hong Son): Rostral nearly one-half wider than high, well visible above; internasals subquadrangular, about half area of prefrontals; frontal as long as its distance from tip of snout, little shorter than parietals; parietals bordered behind by four scales; nostril between two nasals, posterior one largest; loreal present, considerably longer than high; preocular large, reaching top of head but separated from frontal; two postoculars, both touching parietal; temporals, 1 + 2, anterior touching only lower postocular; eight supralabials, fourth and fifth border eye; ten infralabials, first five border first chinshieds which are larger than second pair.

Scale-formula: 23 (occiput), 19, 19, 17. Scales smooth throughout. Ventrals, 214; subcaudals, 66; anal single. Maxillary teeth, 20-21, anterior ones largest.

Color in life: Above dull red to magenta with dark-edged cross-bars, centers of which are practically same shade as body intervening areas double or triple length of cross-bars; two narrow black lines extend straight forward to eyes from first bar; median black line on head from anterior edge of frontal to end of parietals; black edges of cross-bars bordered with lighter color at least anteriorly. Ventrals and subcaudals ivory-white except on outer edges; chin ivory-white; supralabials and top of head grayish brown; a pair of dorsolateral black lines begin at about 12th cross-bar, extending backwards.

Measurements in mm. (Nos. 20926 and 36526): Total length, 983, 307; tail, 156, 51; width of head, 16, 6.7; length of head, 28.5, 14.4.

Variation: The young specimen, No. 36526, is from Doi Suthep, collected by O. Gordon Young. The bands are coal black, 14 in number on body, and four on tail; the dorsolateral bands begin on the twelth bar.

There are nine supralabials (the third being divided probably abnormally, thus the fifth and sixth border eye). The second pair of chinshields are transversely divided leaving three pairs of chin-

shields. Ten lower labials present, the median stripe on head reaching to the internasals. The first temporal touches neither of the postoculars but both touch the parietal. The ventrals are 208, subcaudals, 69; the anal is divided.

The known ventral range is 190 to 218; the subcaudal range, 52 to 76.

Distribution: The snake has been taken only in northern Thailand in mountains. It is known from the provinces of Mae Hong Son, and Chiang Mai.

Outside of Thailand the species occurs in the Eastern Himalayas, Assam, Burma, Yunnan, west China, northern Malaya, and Sumatra. No specimens have been reported between Doi Suthep, Chiang Mai and the Cameron Highlands (4500 ft. elev.) in northern Malaya.

Elaphe flavolineata (Schlegel)

(Fig. 25)

Coluber flavolineata Reinwardt, Bull. Sci. vol. 9, 1826, p. 237 (*nom. nud.*); Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 141 (type-locality, Java); Stejneger, Nyt. Mag. Naturvid. Kristiana, vol. 60, 1922, (2), p. 78.

Coluber melanurus (*non* Shaw 1802) Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 141, pl. 5, figs. 11, 12 (type-locality Java); Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 334; Catalogue of the snakes in the British Museum, vol. 2, 1894, pp. 60-61; Annandale, Journ. Asiat. Soc. Bengal, new series, vol. 1, 1905, p. 173; M. Smith, Journ. Nat. Hist. Soc. Siam., vol. 2, no. 2, 1916, pp. 160-161; Wall, Journ. Bombay Soc. Nat. Hist., vol. 29, 1923, p. 261. M. Smith, Bull. Raffles Mus., no. 3, 1930 p. 48.

Composoma melanurum: Günther, The reptiles of British India, 1864, pp. 244-245.

Elaphe melanurus: Barbour, Mem. Mus. Comp. Zool., Harvard Coll. vol. 44, 1912, p. 117; Sworder, Singapore Nat., no. 2, 1922, p. 63, (Singapore).

Elaphe flavolineata: M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 48; The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 148-149.

Diagnosis: A large snake reaching approximately one-and-one-half meters in length; color black and yellowish brown; loreal not particularly small; the last labial touching eye also in contact with temporal scales; scales on posterior two thirds of body strongly keeled; scales in 19 rows; ventrolateral spots on anterior part of body; two dark spots radiating below eye; no transverse bar on neck; posterior part of body and tail (above and below) black; a pair of dorsolateral black lines on anterior part of body.

Description of species (from EHT-HMS No. 9. Kuala Lumpur, Malaya): Rostral one-and-one-third times as wide as high, very narrowly visible above; internasals as wide as long, much smaller

than prefrontals, little wider than long; frontal scarcely angulate anteriorly, nearly triangular, its length equal to its distance from rostral, equal to common parietal suture but shorter than parietal scutes; nasal divided, posterior part largest; loreal longer than high; one large preocular reaching upper side of head but not touching frontal; two postoculars; temporals, 2 + 2, both anterior temporals touching sixth labial; supralabials, 9-9, fourth, fifth, and sixth bordering orbit; mental small, its labial border much less than that of rostral; infralabials, 10-11, six touching first pair of chinshields which are larger, but approximately same length as second pair.

Scale-formula: 21, 19, 17; anteriorly 11 rows keeled, 17 rows more posteriorly; outermost row unkeeled throughout. Ventrals, 227, somewhat angulate laterally; anal, single, subcaudals, 104.

Color: Head above and on sides uniform olive-brown; supralabials yellow-ivory except along their upper edges; a blackish bar below eye extending across infralabials; a diagonal black bar from eye across supralabials terminating on the eighth; a black stripe from posterior temporals to first ventrolateral black spot on ninth and tenth ventrals; at level of twentieth ventral, a pair of dorsal black stripes begin, separated mesially by three scalrows, the stripes two scalerows wide; these continue back to about level of the one hundredth ventral; area between black stripes yellow-brown; from the termination of the lines the brown of back gradually darkens to black continuing so to end of tail. Anteriorly on outer edge of ventrals a series of twelve black spots, often extending onto first scalerow; above these on side a lighter area, then a short black mark with another lighter area between this and the black dorsal stripe.

The light areas associated with black spots extend onto the skin between scales.

Measurements in mm.: Snout to vent, 1095; tail, 324; total length, 1419; width of head, 17; length of head, 31.5.

Variation: Ventrals vary between 193 and 234; subcaudals, 89 and 115. The young may have ocelli with bright yellow centers associated with the black spots. The scales about neck may be in 21 or 19 rows.

Distribution: In Thailand the species has been found only at "Bangnara" [= Narathiwat], in the province of that name.

The species is widespread occurring in the Indo-Australian Archipelago, Malaya, Nicobar Island, Andaman Islands and Burma. I have not found it in Thailand, and I use a Malayan specimen for the description.

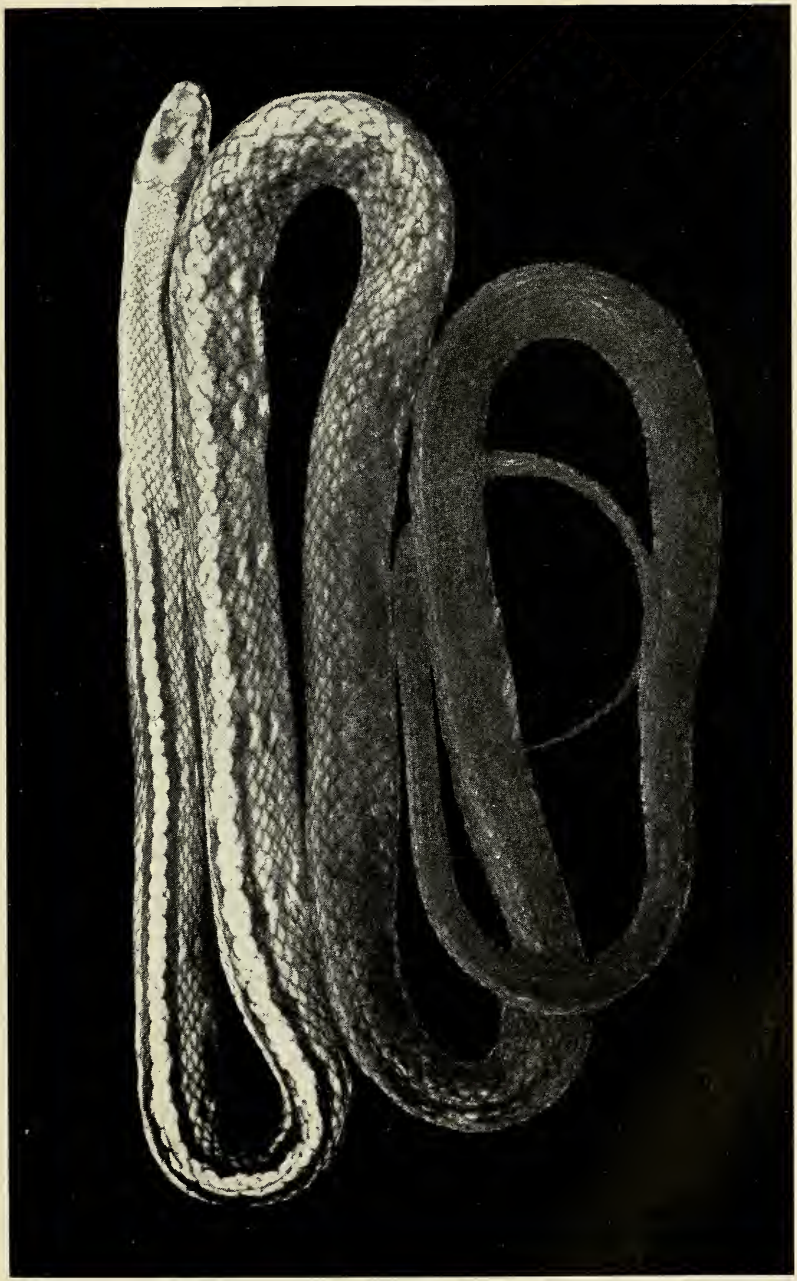

FIG. 25. *Elaphe flavolineata* (Schlegel). EHT-HMS No. 9, Kuala Lumpur, Selangor, Malaya. Actual total length, 1419 mm.; tail, 324.

Genus *Ptyas* Fitzinger

Ptyas Fitzinger, Systema Reptilium, 1843, p. 26 (type of genus, *blumenbachii*).

Zamenis Gagler, Natürliches System der Amphibien 1830, p. 188 (type of genus *Aesculapii* Lacépède [non Linnaeus] "Aescaulapechlange").

Dignosis: Large snakes, with head distinct from the more or less cylindrical body; eye large to very large, the pupil round; scales in 17-15 rows (more rarely 18, 16, 14); subcaudals, paired; apical pits present; normally two or three loreals; a presubocular usually present.

Maxillary teeth, 20 to 28, increasing slightly in length and thickness posteriorly.

Three species occur in Thailand. They are large, conspicuous snakes that move very rapidly on the earth, and at least one is a good tree climber. They may be separated by the following key:

KEY TO SPECIES OF *Ptyas* IN THAILAND

1. Number of scalerows never in even numbers; scales in 15 rows at middle of body; ventrals less numerous, 160-187 subcaudals, 120-147; young with white bands; adults showing lineation in posterior part of body..... *korros*
   Scalerows often even or at least so in posterior part of body..... 2
2. Scales in 17 or 16 rows at middle of body; ventrals more numerous 190-213, subcaudals, 100-146; darker bands at least in posterior part of the body, that may be somewhat reticulated or not; labials and neck scales with black sutures..... *mucosus*
   Scales only in even number of rows, 16 or 14 rows at middle of body, the median rows (four or six) keeled; ventrals, 200-215, subcaudals, 110-118, yellowish brown on posterior part of body with six black irregular longitudinal stripes tending to form a reticulation..... *carinatus*

Ptyas korros (Schlegel)

(Figs 26, 27)

Coluber korros Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 139; Abbildungen . . . Amphibien, 1840, p. 99, pls. 27-28, figs. 1-6 (type-locality, Java); Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 121.

Ptyas korros: Günther, The reptiles of British India, 1864, p. 250; Theobald, Journ. Linn. Soc., Zoology, vol. 10, no. 41, May, 30, 1868, p. 46. Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 54, 65; Sclater, Hand list of the snakes in the Indian Museum, 1891, p. 26; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 94, 187; *ibid,* vol. 6 pt. 3, 1915, p. 213; *ibid,* vol. 2, 1916, p. 16 (Pattani, Nakhon Si Thammarat); Sworder, Singapore Nat., vol. 2, 1922, p. 62; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, no. 2, 1923, p. 202; Kopstein, Treubia, vol. 11, 1930, p. 301, fig.; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 47; Pope, The reptiles of China, 1935, pp. 217-220; Taylor, Proc. Acad. Nat. Hist. Soc. Philadelphia, vol. 86, 1936, p. 305 (Chantaboon = Chanthaburi, Chanthaburi province); Bourret, Les serpents de l'Indo-Chine, 1936, p. 176; Shaw, Shebbeare, and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 14, 1939, p. 71; M. Smith, The Fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 162-163; Tweedie, The snakes of Malaya, 1954, p. 43, fig. 8 (Second Ed., 1957); Taylor and

Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1136 (Chaiyaphum and Kalasin provinces).

Zamenis korros: Boulenger, The fauna of British India, Ceylon, and Burma, Reptilia and Batrachia, 1890, p. 324; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, pp. 384-385; *ibid,* vol. 3, 1896, p. 621, in Addenda; Flower, Proc. Zool. Soc. London, 1899, p. 666; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900-1901, p. 353, 620; Wall, *ibid,* vol 18, 1908, p. 326; *ibid,* vol. 19, 1909, pp. 345, 622; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 137; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 618.

Ptyas korros chinensis Mell, Sitz. Ber. Ges. Nat. Freunde, Berlin, 1930, p. 320 (type-locality, Yao-shan, Kwangsi, China).

Ptyas korros indicus Mell, Lingnan Sci. Journ., vol. 8, p. 208 (type-locality SW Yunnan, China).

Liopeltis libertatis Barbour, Proc. Biol. Soc. Washington, vol. 23, p. 169 (type-locality, Buitenzorg, Java); Dunn, Amer. Mus. Novitates, No. 287, 1927, p. 1.

Diagnosis: Large snakes reaching a length of at least two meters; young gray on anterior half of body with dotted blue-white transverse bars, tending to disappear in older individuals which become nearly uniform brown or gray-brown anteriorly; scales may be slightly edged with white; farther back this white portion widens forming eleven pale longitudinal lines, separated by brownish or grayish lines.

Three (two) loreals; one presubocular; scalerows: 15, 15, 11; ventrals, 160-187.

Description of species (from No. 34162 ♀ Bangkok): Rostral wider than high, narrowly visible above; internasals about two thirds area of prefrontals; latter scales touching two (one) loreals laterally; frontal longer than wide, longer than its distance from end of snout, as long as parietals; nasal divided, anterior portion the largest, anterior edge of posterior part deflected downward; three (two) loreals; large preocular reaching top of head but not touching frontal; supraoculars forming a slight shelf above eye and preocular region; small presubocular wedged between third and fourth supralabials; two postoculars, upper largest; temporals, $2 + 2 + 2$, upper anterior touching both postoculars; supralabials eight, fourth and fifth bordering eye; infralabials ten, first five touching first chinshields which are smaller than second pair; latter scales touch each other anteriorly, separated by two scales posteriorly; eye large, its length equal to its distance from nostril. Scale-formula: 20 (occiput), 15, 15, 11, scales smooth. Ventrals, 170; subcaudals, 104; anal, divided.

Color: Head and anterior part of body gray-brown (bluish gray when epidermis is shed); scales with grayish-white edges, at first

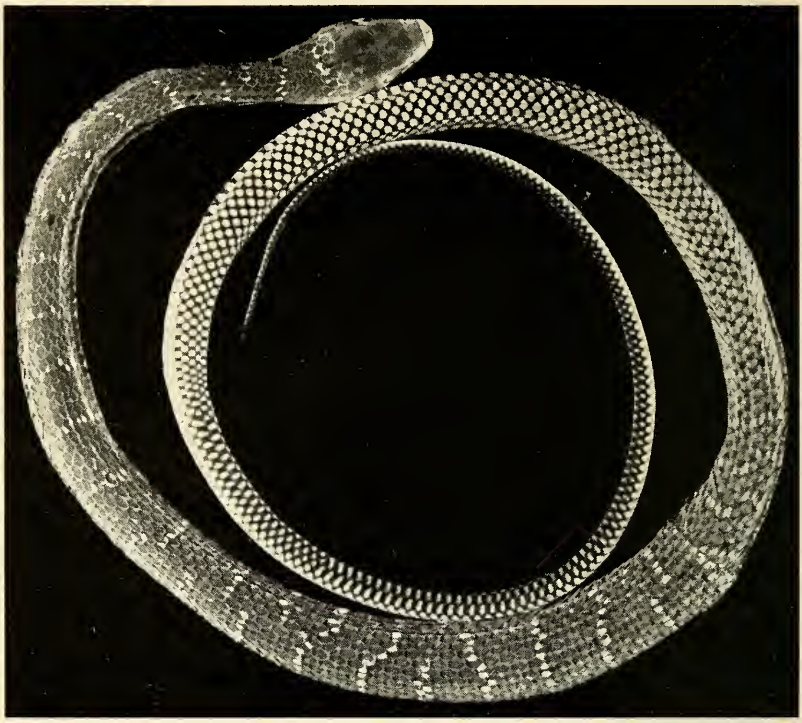

FIG. 26. *Ptyas korros* (Schlegel). No. 33310 young, Muak Lek, Sari Buri province, central Thailand. Actual total length, 593 mm.; tail, 211 mm.

scarcely noticable but farther back light edges of two scalerows make pale lines that widen posteriorly and are separated by lines of brownish ground color; farther back this dark color becomes black, concentrated chiefly in a single median posterior spot on the scale with a slightly darker edging; major part of each scale on posterior fifth or sixth of body and on tail, ivory-white; labials, chin, and ventral surface brownish white to nearly ivory; white posteriorly in subcaudal region; sides and tip of snout whitish.

Measurements in mm.: Total length, 1402; tail, 443; width of head, 19; length of head, 35.

Distribution: The species occurs throughout Thailand in lowlands. It has been taken in the provinces of Yala, Trang, Narathiwat, Pattani, Phattalung, Nakhon Si Thammarat, Bangkok, Sara Buri, Khorat, Chaiyaphum, Kalasin, Chiang Mai and Chon Buri.

Outside of Thailand the species ranges in Assam and Burma, Laos, South China, Cambodia, Malaya, Sumatra, Java, and Borneo.

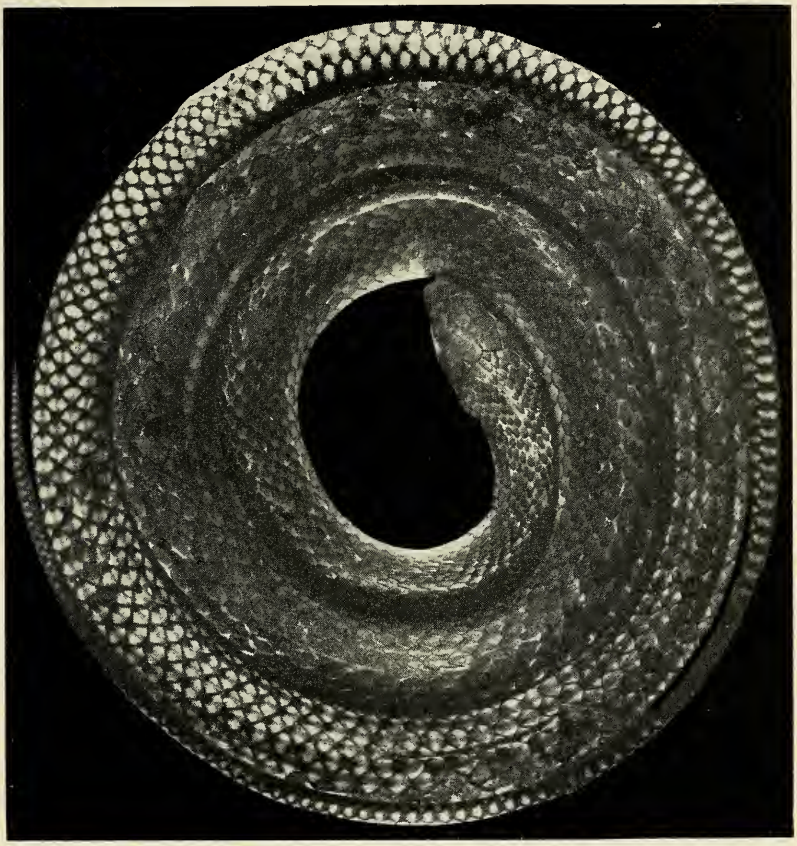

FIG. 27. *Ptyas korros* (Schlegel). No. 34162, Bangkok (city). Actual total length, 1402 mm.; tail, 443 mm.

Remarks: This large snake is one that is frequently mistaken for the King Cobra. Needless to remark, the species is entirely harmless, feeding largely on frogs, rats, and other small rodents and occasionally on other reptiles and birds.

They are often seen in bushes and low trees especially in the neighborhood of water. They remain quiet and one may approach quite close to them if the approach is quiet and slow. When in grass the head may be raised thus looking even more like the Hamadryad.

The young have numerous narrow whitish bars and look very different from the adults.

The species lays eggs, usually not more than twelve. When hatched, the young measure about 375 millimeters in length.

Ptyas mucosus (Linnaeus)

(Fig. 28)

Coluber mucosus Linnaeus, Museum Adolphi Friderici Regis, vol. 1, 1754, p. 37, pl. 23; Systema naturae, ed. 10, 1758, p. 226 (type-locality, India) based on Russell, An account of Indian serpents collected on the coast of Coromandel, vol. 1, 1796, p. 40, pl. 34; Andersson, K. Sven. Vet-Akad. Handl. Stockholm, vol. 24, 1899, p. 25.

Zaocys mucosus: Wall, Journ. Bombay Nat. Hist. Soc., vol. 23, p. 168; *ibid.*, vol. 26, p. 566; Spolia Zeylanica, 1921, p. 399.

Ptyas mucosus: Günther, The reptiles of British India, 1864, p. 249; Theobald, Journ. Linn. Soc. vol. 10, no. 41, Zoology, May 30, 1868, p. 46; Blanford, Proc. Zool. Soc. London, 1881, p. 221; Tirant, Notes sur les reptiles et les Batraciens de la Cochinchine et du Cambodge, 1885, pp. 54, 55, 65; Wall, Ophidia Taprobanica or the snakes of Ceylon, 1921, pp. 172-190, fig. 40; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 617; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, (1), 1924, p. 169; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, no. 2. Oct. 1923, p. 202 (Hainan); M. Smith, Bull. Raffles Mus. no. 3, 1930, p. 47; Subrahmaniam, Journ. Bombay Nat. Hist. Soc., vol. 37, 1934, p. 743; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, pp. 304-305 (Chiang Mai); Pope, The reptiles of China, 1935, pp. 220-223; Fraser, Journ. Bombay Nat. Hist. Soc., vol. 29, 1937, p. 475; Shaw, Shebbeare and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 14, 1939, p. 68; Taylor, Univ. Kansas Sci. Bull., vol. 33, pt. 2, Mar. 20, 1950, pp. 543, 544 pl. 15, fig. 1; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1135 (Nakhon Pathom province).

Zamenis mucosus: Boulenger, The fauna of British India, including Ceylon and Burma, Reptilia and Batrachia, 1890, p. 324; Catalogue of the snakes in the Bristish Museum, 2nd Ed., vol. 1, 1893, pp. 385-386; Ferguson, Journ. Bombay Nat. Hist. Soc., vol. 10, 1895, p. 71; Beadon, *ibid.*, vol. 20, 1910, p. 228; Millard, *ibid.*, vol. 17, 1906, p. 245; Venning, *ibid.*, vol. 20, 1910, p. 339; Millet, *ibid.*, vol. 19, 1909, p. 758, 759; Fenton, *ibid.*, vol. 19, 1910, p. 1002; Wall, Journ. Bombay Nat. Hist. Soc., vol. 17, 1906, p. 259, pl. 3; *ibid.*, 17, 1907, p. 259, *ibid.*, vol. 18, 1907, p. 113; *ibid.*, vol. 19, 1909, p. 622; *ibid.*, vol. 21, 1911, p. 134; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 137-138; Nikolski, Faune de la Russie, vol. 2, 1916, p. 79; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 98; McCann, Journ. Bombay, Nat. Hist. Soc., vol. 38, 1935, p. 409; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, pp. 304-305 (Chiang Mai prov.); Bourret, Les serpents de l'Indochine, 1936, p. 178.

Zaocys mucosus: Wall, Journ. Bombay Nat. Hist. Soc., vol. 23, 1914, p. 168; *ibid.*, vol. 26, 1919, p. 566.

Coluber blumenbachii Merrem, Tentamen systematis amphibiorum, 1820, p. 119 (type-locality, Bengal).

Coluber dhumna Cantor, Proc. Zool. Soc. London, 1839, p. 51 (type-locality, "Carnatic Orissa, Bengal, Nepal, Asám, Arracan, Tenasserim").

Leptophis trifrenatus Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 503 (type-locality, Hong Kong).

Diagnosis: Large snakes bearing a superficial resemblance to the king cobra and to the large rat snake *Ptyas carinatus;* "reaching a length of 11 ft. 9 in."

Scales usually in 17 (or 16) rows; ventrals, 190-213; subcaudals, 121-146. Maxillary teeth, 20-25, more or less subequal; sutures of supralabials and infralabials blackish, with numerous blackish marks

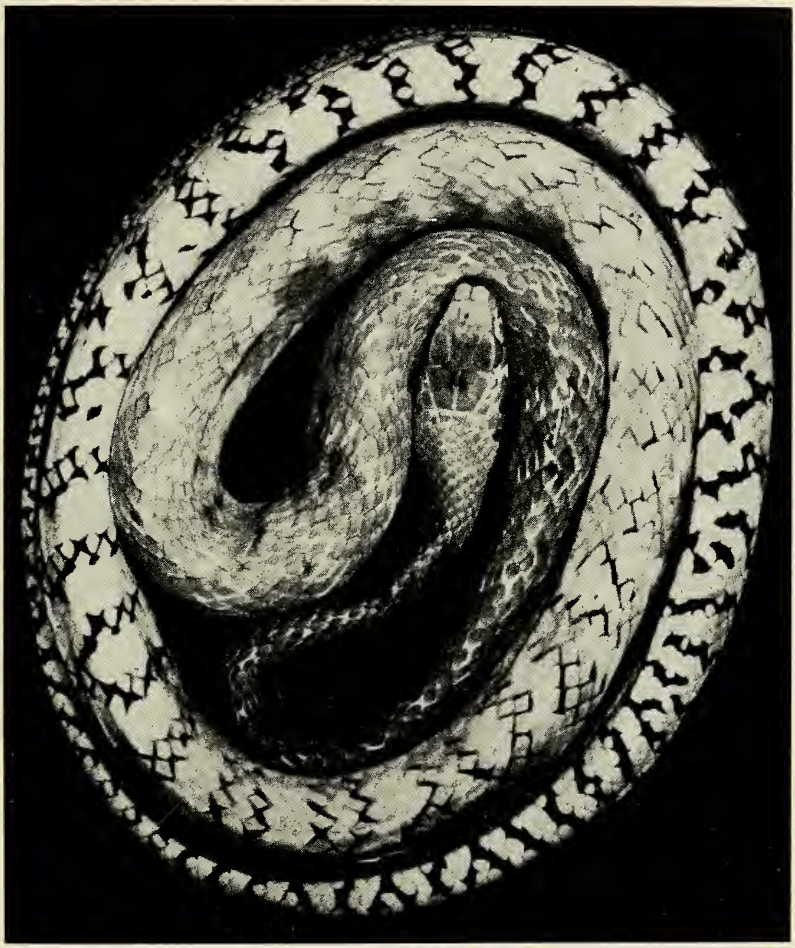

FIG. 28. *Ptyas mucosus* (Linnaeus). No. 17, Bangkok (city), Thailand. Actual total length, 1702 mm.; tail, 439.5 mm.

on chin and forepart of neck (ventral); narrow irregular dark-brown bands on posterior part of body.

Description of species (from No. 34165, Bangkok): Rostral wider than high, narrowly visible above; internasals longer than wide, of about half area of prefrontals; latter bordering two loreals, wider than long, the sides bent down; frontal as long as wide, distinctly shorter than its distance from rostral; only very slightly shorter than parietals; latter scales about a fourth longer than wide; nasal divided, anterior part largest, posterior part with its anterior edge deflected

downwards; three small loreals; two preoculars, upper large, its upper part reaching top of head and with supraoculars forming a small projecting shelf above and in front of eye; two postoculars; temporals, 2 + 2; supralabials, 8-9, the fourth and fifth bordering eye; ten infralabials, five bordering first pair of chinshields which are distinctly shorter than second pair; latter in contact anteriorly, separated by one or two small scales posteriorly.

Scale-formula: 24 (occiput), 21, 17(16), 14, smooth with paired apical pits. Ventrals, 197; subcaudals, 117; anal, divided.

Color: Head dark brown above (with epidermis removed, fawn to gray); snout yellowish; labials yellowish with black sutures on both supra- and infralabials; scales on neck and anteriormost ventrals similarly marked; body amber to brown, latter three fourths of body with narrow irregular bands or alternating broken bands on top and sides of body, passing on to venter but not crossing it (sometimes forming a reticulum above); numerous brownish spots on underside of posterior ventrals and subcaudals; venter light yellowish brown anteriorly, growing more yellowish posteriorly; subcaudals yellowish ivory.

Measurements in mm.: Total length, 1753; tail, 463; width of head, 28; length of head, 47.

Distribution: Found widely distributed in Thailand. Outside of Thailand the range extends from Transcaspia east through India, Ceylon to Indochina, and Malaya.

Remarks: This species is somewhat less common than *Ptyas korros,* and when specimens are found with the scalerows 16 and 14 it is difficult to distinguish them from *Ptyas carinatus* which likewise has an even number of scalerows and three loreals. Moreover, *mucosus* may have the median scales keeled. Under these circumstances the color differences will serve to distinguish them.

Ptyas carinatus (Günther)

Coryphodon carinatus Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858, p. 112 (type-locality, Borneo).

Zaocys carinatus: Günther, The reptiles of British India, 1864, p. 256 (footnote "Our largest example is nearly 10 feet long, the tail being one-fourth"); Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 377, pl. 27, fig. 1; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 324; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 135-136; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 160 ("Patani," Nakhon Si Thammarat, "Northern Siam"); de Rooji, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 73 (Malay Peninsula, Sumatra, Java, Borneo); Sworder, Singapore

Nat., no. 2, 1922, p. 62, (Singapore); Joynson, Journ. Nat. Hist. Soc. Siam, vol. 6, 1927, p. 314; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 46; Bourret, Les serpents de l'Indochine, 1936, p. 173, fig.; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 164-165.

Ptyas carinatus Wall, Journ. Bombay Nat. Hist. Soc., vol. 31, 1926, p. 562.

Diagnosis: Maxillary teeth, 22-26; internasals two thirds of the length of prefrontals; two to four loreals; eight to ten supralabials, fourth and fifth or fifth and sixth bordering orbit. Scale-formula: 18, 16 (14), 12; four to six median scalerows keeled.

Description of species: Rostral broader than high narrowly visible from above; internasals shorter than prefrontals; frontal somewhat longer than broad about as long as its distance from tip of snout, shorter than parietals; parietals a little longer than broad; supraoculars about as wide as frontal; nasal divided, anterior part a little the larger; loreals, two (three or four rarely); a preocular reaching top of head but not touching frontal; two postoculars; temporals, 2 + 2; supralabials nine, fifth and sixth border orbit; infralabials eleven, five bordering anterior chinshields which are distinctly shorter than posterior.

Scalerows: 18, 16 (14), 12, four to six median scalerows with keels: ventrals, 208-215; subcaudals, 109-117; anal, divided.

Color: Olive-brown to blackish on anterior part of body with more or less distinct cross-bands and yellowish-fawn spots; gradually ground color becomes buff-brown or yellowish brown posteriorly with a large black network; underside of head and venter yellowish anteriorly, black and yellowish posteriorly.

Measurements in mm.: Total length, 3000; tail, 750.

Variation: The ventral and subcaudals show rather a limited amount of variation; for the ventrals, 208-215; for subcaudals, 110-118. Supralabials vary from eight to ten, and the number of loreals may be two, three, or four.

Distribution: The species occurs widely in Thailand, specimens being known from Lampang (Me Pow Forest, 20 mi. E. of Muang Ngow); Chiang Mai, Nakhon Si Thammarat, Pattani (or Yala). Outside of Thailand the species ranges through Malaya, Singapore, Borneo, Java, Sumatra, to Palawan (Philippines).

Remarks: This is not a rare snake but many specimens taken fail to preserve well because of their size and consequently are discarded. The snake is used much for food.

This species has long been retained in the genus *Zaocys*. The definitions of the two genera *Ptyas* and *Zaocys* are very similar and the similarity between *Ptyas korros*, *Ptyas mucosus*, and *Zaocys carinatus* is such that it seems well to place them together. The chief difference in the genera was presumed to be that *Zaocys* had an even number of scalerows, and *Ptyas* an uneven number. It has been found that *Ptyas mucosus* very frequently may have the scalerows in even numbers throughout a part or even over very much of the body. In *Ptyas korros* there is an odd number of scalerows.

Thus it would appear that *Ptyas mucosus* breaks down the essential distinction that would warrant separation and a recognition of two genera. In consequence I follow Wall, *loc. cit.* in making *Zaocys* a synonym of *Ptyas*, the older name. Malcolm Smith has maintained them as separate genera.

Genus *Lycodon* Boie

Lycodon Boie, *in* Ferussac's, Bull. Sci. Nat., vol. 9, 1826, p. 238 (*part.*); Fitzinger, Neue Classification der Reptilien, 1826, pp. 29, 30 (type of genus, *Lycodon aulicus*). M. Smith, Fauna British India . . . Serpentes, 1943, pp. 255-257, fig. 88.

Ophites Wagler, Natürliches System der Amphibien, 1830, p. 186, (type of genus, *O. subcinctus*).

Diagnosis: Small snakes not reaching one meter in length (except *subcinctus*). Head distinctly flattened, slightly distinct from body; eye with vertically elliptic pupil; body rather short; scales usually in 17 rows (one species 15, one 19 rows), with apical pits; some forms with lateral keels on ventrals; subcaudals (except in one Indian species) paired. Hypapophyses absent on posterior vertebrae. Maxillary arched with three or four small teeth preceding two enlarged teeth, then a curving diastema followed by 7 to 15 teeth, of which the last two are enlarged; nostril between two nasals, or nasal only partially divided; loreal in contact with internasal or not, the scale elongated; three supralabials, third, fourth, and fifth bordering eye; anal normally divided.

The genus is distributed from Transcaspia throughout the Oriental Region, south through Malaya and the Indo-Australian Archipelago.

Approximately 20 species are known, four of which occur in Thailand. They may be differentiated by the following key:

KEY TO THAI SPECIES OF *Lycodon*

1. No preocular present; prefrontal and loreal border eye; scales feebly keeled; one anterior temporal; posterior nasal higher than anterior; usually eight supralabials; ventrals 197-230 ..... *s. subcinctus*

   A preocular separating prefrontal from eye; loreal separated from border of eye, or not; scales smooth or keeled.

2. Snout not projecting beyond lower jaw; loreal usually just touching or separated from internasal: two anterior temporals; nine supralabials; first chinshields two to three times size of second pair..... *laoensis*
   Snout projecting beyond lower jaw.
3. Scales smooth; ventrals strongly angulate; nasals subequal; loreal in contact with internasal, not touching eye; a white or yellow nuchal band, speckled with lavender; body reticulated with lavender and fawn . . *capucinus*
   Median scalerows feebly keeled; ventrals feebly angulate; posterior nasal larger than anterior; loreal borders eye, well separated from internasal; no white or yellow nuchal band; numerous transverse light and dark bands, the dark ones becoming narrower posteriorly..... *fasciatus*

Lycodon subcinctus subcinctus Boie

Lycodon subcinctus Boie, Isis, 1827, p. 551 (Based on Russel, Indian Serpents, vol. 2, 1801, p. 44, pl. 41, (type-locality, Java); Boulenger, Catalogue of the snakes in the British Mus., vol. 1, 1893, pp. 359-360; Flower, Proc. Zool. Soc. London, 1899, p. 665; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 133-134; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 108, 109, fig. 45; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 160 (Pattani); Sworder, Singapore Nat., no. 2, 1922, p. 62; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 202; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 46 (Gunong Tahan, Malaya, 5400 ft.).

Ophites subcinctus: Günther, The reptiles of British India, 1864, p. 322; Blanford, Proc. Zool. Soc. London, 1881, p. 222, pl. 21, fig. 2; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, p. 46; Bourret, Les serpents de l'Indo-chine, 1936, p. 157; Pope, Reptiles of China, 1935, pp. 196-197, fig. 45 (head); Herklots, Hong Kong Nat., vol. 6, 1935, p. 195, fig. (head).

Elapoides annulatus Sauvage, Bull. Soc. Philom., ser. 7, vol. 8, p. 144 (type-locality, Sumatra).

Lycodon platurinus Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 916.

Diagnosis: Scales in 17 rows; no preocular present, permitting both prefrontal and loreal to border eye; scales feebly keeled; young with 10-13 broad purplish-black bands separated by white crossbars; white bars lost in posterior part of body in adult specimens, and only a trace of the white remains in old specimens. Reaching a length of one meter.

Description of species (from No. 35656, Tonka Harbor Tin mine, Ronpibon, Nakhon Si Thammarat): Snout broad, depressed; rostral about a third wider than high, very slightly visible above; internasals less than half area of prefrontals, the suture between them half that between prefrontals; latter scales about as wide as long, bordering eye; frontal wider than long, its length equal to or slightly shorter than prefrontals, more than twice width of a supraocular; parietals elongate, their length only a little less than their distance from rostral; nasal divided, anterior part quadrangular, the posterior part larger, subtriangular; nostril large; loreal nearly twice as long as high bordering eye, touching three supralabials, but separated widely from internasal; no preocular, two postoculars; temporal formula: 1 + 2 + 3; eight supralabials, fourth and fifth

(on left side, third, fourth, and fifth) bordering eye; eye with a vertically oval pupil; infralabials nine, four bordering the anterior pair of chinshields which are much larger than second pair.

Scale-formula: 20 (occiput), 17, 17, 15, the median ten rows with weak keels. Ventrals, 216, laterally angulate with a slight notch on each side; anal, divided; subcaudals, 83.

Color in life: Dark purplish-black anteriorly, growing somewhat lighter posteriorly; a cream-ivory spot on sides of occiput back of jaw-angle; at level of 23rd ventral an ivory-white band, widest on venter, dorsal portion bearing many blackish scales; second light band begins on a level with fifty-first ventral, represented only by a few scattered ivory spots: third light band is barely indicated by some light flecks on venter with a small lateral spot on one side. Chin and throat grayish white; most ventrals grayish, color more intense on anterior part of each scale; subcaudal region darker gray than venter.

Measurements in mm.: Total length, 923; tail, 173; width of head, 14.3; length of head, 23.

Variation: The typical color pattern of the young consists of 10 to 13 light crossbands surrounding the body, the scales sometimes edged with black; the hinder part of the head white. In specimens from the northern part of the range the white bands are speckled with black and the underside of the tail may be white. The ventrals vary between 197-230,* the subcaudals 71-90; the anal scale is occasionally single. Rarely three postoculars are present.

Distribution: The species while known from a few localities in Thailand presumably ranges over the whole country. Outside of Thailand it is known from Southern China, Laos, Viet Nam, Cambodia, the Malay Peninsula, and the Indo-Australian Archipelago to the Philippines.

Remarks: I captured the described specimen within the hollowed base of a forest tree, ensconsed behind a loose fragment of wood at Ronpibon, Nakhon Si Thammarat. It moved with considerable rapidity. A second specimen was taken at Na Pradoo, Pattani.

Lycodon laoensis Günther

(Figs. 29, 30, 31)

Lycodon laoensis Günther, Reptiles of British India, 1864, pp. 317-318, (type-locality, Laos, French Indo-China); Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 354, pl. 24, fig. 2; Laidlaw, Proc. Zool. Soc. London, vol. 2, 1901, p. 576; Boulenger, A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore, Reptilia and

* De Rooij states 128-230 and 61-90 for subcaudals. I suspect 128 is a typographical error.

Batrachia, 1912, p. 132; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 160; Bull. Raffles Mus., no. 3, 1930, p. 46; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 259-260.

Diagnosis: A small snake (475 mm.); body bluish, or brownish black, with narrow bright yellow or white cross-bars which expand laterally, the expansions enclosing triangular or other spots of same

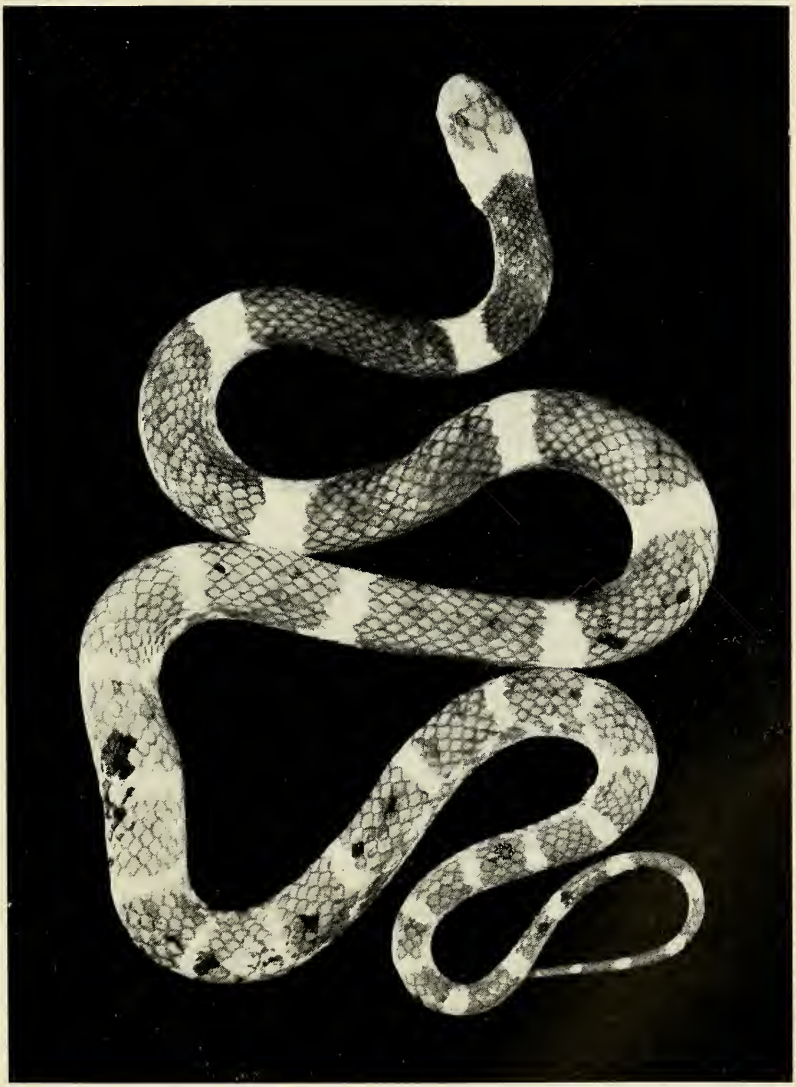

FIG. 29. *Lycodon laoensis* Günther. No. 33308 ♂, one and one-half miles west of Muak Lek, Sara Buri, but actually in the province of Nakhon Ratchasima, Thailand. Actual total length, 445 mm.; tail, 103 mm.

body color; a preocular separating prefrontal from eye, in contact with frontal; loreal elongate, not entering orbit, slightly in contact or not with internasal; anterior and posterior parts of nasal equal or anterior largest. Maxillary teeth in two groups separated by a diastema. A single apical pit on each scale.

Description of species (from No. 33308 ♂ one-and-one-half miles west of Muak Lek, Sara Buri, but actually in Nakhon Ratchasima province): Head moderately distinct from neck, rather flattened, the temporal regions not elevated; rostral much broader than high, part visible above less than half length of prefrontals; internasals less than half area of prefrontals, about as wide as long, their mutual suture about half as long as that between prefrontals; latter scales longer than wide; frontal short, four-fifths as wide as long, shorter than its distance from tip of snout, and much shorter (one third or more) than parietal; supraocular not more than half width of frontal. Nasal divided, anterior part a little larger than posterior; an elongate loreal narrowly touching internasal, but separated from eye by preocular and third labial; preocular large, in contact with the frontal; two postoculars; temporals, $\frac{1}{2} + 4 + 3$; ten supralabials, third, fourth, and fifth entering orbit; ten infralabials, five touching first chinshields which are about three times size of second pair; first pair of infralabials relatively large.

Scale-formula: 24 (occiput), 17, 17, 15; scales-smooth, with a single minute apical pit. Ventrals, 166; subcaudals, 71; anal, divided; ventrals more or less distinctly angulate.

Maxillary teeth: Anterior group of 5, first three small, then two much enlarged; after a curving diastema, eight small teeth, followed by two enlarged teeth that are smaller than the anterior enlarged ones.

Color in life: Above grayish blue, scales a little darker on edges. Top of head ultramarine, the color terminating in a point at terminus of suture between parietals; anterior supralabials same color; posterior labials cream, upper edges of labials bordering orbit, pigmented; a broad yellow band across occiput narrowed mesially. Chin and entire ventral surface yellowish ivory; subcaudal region, gray-white. A series of bright yellow transverse bars cross back, widening laterally and enclosing somewhat triangular spots of dark color; these are as wide as three transverse scalerows anteriorly but narrow posteriorly to width of one row (these without lateral spots). The spacing of dark blotches is different; the nuchal dark blotch

FIG. 30. *Lycodon laoensis* Günther. No. 33630 ♀, Chiang Mai, Chiang Mai, Thailand. Actual total length, 404 mm.; tail, 77 mm.

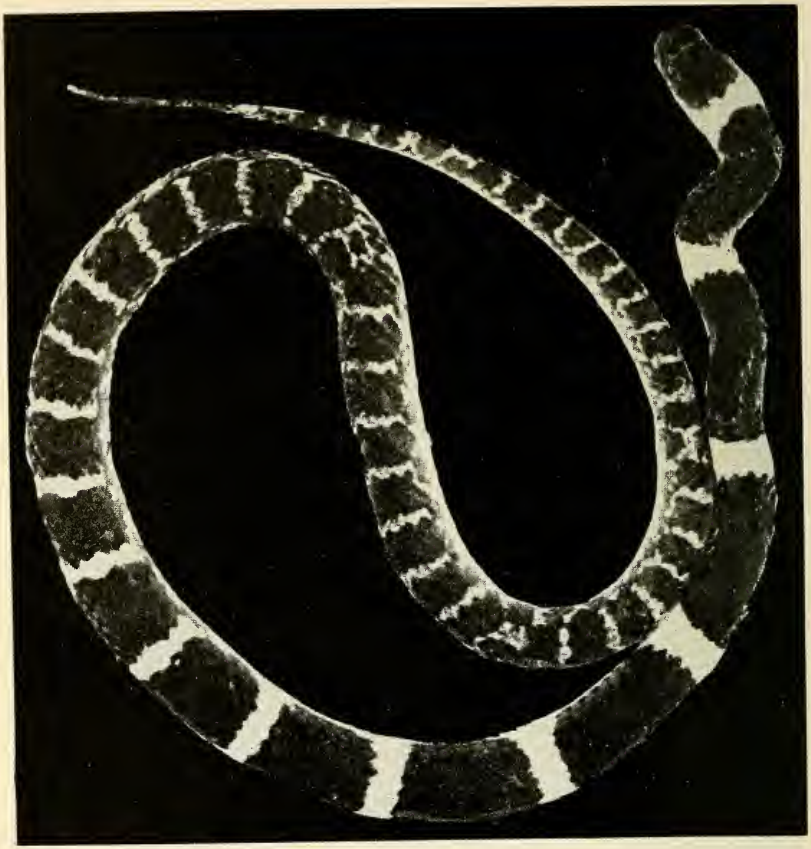

FIG. 31. *Lycodon laoensis* var. No. 34529 ♂, Pattani, Pattani province. Actual total length, 335 mm.; tail, 69 mm.

covers 17 transverse scalerows, and the eight succeeding ones cover 14, 14, 11, 9, 10, 9, 8, 6, transverse scalerows while the following ten body blotches cover either five or six; 14 blotches on tail; nowhere do spots or blotches reach ventrals; outer edges of subcaudals may have some pigment.

Variation: The known variation in ventrals is from 163 to 187; of subcaudals, 60 to 76. In Thailand specimens the ventral scales of the males vary from 165 to 187; the subcaudals, 60-73; females vary from 163 to 181, and 62 to 76.

The Chiang Mai specimens have a slightly narrower occipital light band, and there appears to be a stronger constriction of the head on a level with the eyes; one specimen differs in having the prefrontal and frontal fused at a narrow isthmus.

Measurements and scale data on *Lycodon laoensis*

NUMBER	33308	33630	33631	33629	33632	34529	36130	36549	249
Sex	♂	♀	♀	♀	♂	♂	♂	♂	♂
Total length	445	404	412	437	383	335	376	383	498
Tail	103	77	79	75	78	69	80	90	107
Head, width	9	8	8	8.5	8	7	7.8	8.1	10
Head, length	14	14	14	13.8	14	12.4	14.3	14.2	16
Ventrals	166	169	178	181	172	163	165	164.5	175
Subcaudals	71	64	65	62	65	65	64	76	71
Anal	2	2	2	2	2	2	2	2	2
Scale-formula	17–15	17–15	17–15	17–15	17–15	17–15	17–15	17–15	17–15
Preocular	1	1	1	1	1	1	1	1	1
Postocular	2	2	2	2	2	2	2	2	3–2
Supralabials	10–10	9–9	9–9	9–9	9–9	9–9	9–9	9–10	9–9
Infralabials	10–10	9–10	10–10	10–10	10–10	10–10	9–9	10–10	10–11
Anterior nasal largest	yes	=	yes	yes	yes	=	yes	=	yes
Black blotches body	19	21	26	23	20	36	25	23	25
Black blotches tail	14	11	12	15	12	22	15	15	21*

* An approximation. The separating light bars are darkened in the posterior part of body and on tail, so that an accurate count cannot always be made.

A specimen (No. 249) from Na Bon, Nakhon Si Thammarat was found precariously clinging to the almost-smooth surface of the trunk of a rubber tree about ten feet from the ground. Another was found under a small pile of dry grass. No. 249 contains a portion of a small *Mabuya multifasciata*. No. 36130, a male from Chiang Mai, contains a partly digested specimen of a *Leiolopisma*. Two Chiang Mai specimens (Nos. 33629, 33630) contain eggs, one four, the other three. No. 249 has an unusual parasitic worm embedded below the skin on one side. The parasite is approximately 20 millimeters in length and from 1.5 to 2 millimeters in diameter.

In the described specimen the loreal makes strong contact with the internasal while in most specimens it barely touches or does not touch the scale. There are fewer blotches on the body than in the other specimens.

A specimen from the extreme southern border of the range, was taken in the city of Pattani in the province of the same name (No. 34529). It differs in having 36 dorsal bands with 22 on the tail. In this, the loreal is well separated from the internasal on one side (other side injured); the preocular is separated from the frontal on one side, touching only at a point on the other; the anterior temporals are superimposed and are of approximately the same size. The temporal formula is: $2 + 3 + 4 + 4$. A second southern specimen No. 3862 has been taken at Trang (Forest station).

Distribution: Found throughout Thailand. Outside of Thailand it is known from Malaya, Laos, Cochin China and Southern Viet Nam.

Remarks: The specimen described was dislodged from under loose bark on a tree at an elevation of nearly 30 feet above the ground.

Lycodon laoensis has developed certain variations which appear to be worthy of mention and sufficient southern material may permit subspecific designation for a southern form (figure given).

The typical form was described by Günther (1869) from Laos Mountains—two specimens "a male and a female, are perfectly alike." There are 185 ventrals and 68 subcaudals in the male. "Abdomen and tail with a distinct angular ridge on each side in the male, indistinct in the female"; "preocular single, in contact with vertical [frontal] and with the third labial"; "two postoculars"; "a third specimen has been purchased and is said to be from Siam"; Boulenger (1893) adds the following details, "temporals $2 + 3$".

Table contrasting body blotches and ventrals of *Lycodon laoensis*

	Body blotches	Tail blotches	Sex	Total blotches	Ventrals	Sub-caudals	Totals	Numbers	Localities
Types	?	.....	♂	?	179	68	247	B.M.a.	Laos Mts.
	?	.....	♀	?	185	68	253	B.M.b.	Laos Mts.
	?	.....	♀	?	183	73	256	B.M.c.	"Siam"
	19	14	♂	33	166	71	237	33808	Muak Lek
	20	12	♂	32	172	65	237	33632	Chiang Mai
	21	11	♀	32	169	64	233	33630	Chiang Mai
	23	15	♀	38	181	62	243	33629	Chiang Mai
	23	15	♂	38	164½	76	240½	36549	Doi Pna Tao*
	25	15	♂	40	165	64	229	36130	Chiang Mai
	26	12	♀	38	178	65	243	33631	Chiang Mai
	25	21	♂	46	175	71	246	249	Na Bon
	36	22	♂	58	163	65	228	34529	Pattani
	27	23	♂	50	171½	71	242½	3862	Trang
	?	?	?	42	176	69	245	?	Kedah

* Near Mt. Intanon.

Ventrals and subcaudals for the Siamese specimen are 183 and 73.

The specimens in the preceding table have been arranged in a north-south series to contrast number of spots and ventral scales:

One must regard the northern specimens as typical. In northern mainland Thailand the number of bands is from 19 to 26 on body; 11 to 15 on tail. In the southern (peninsular) part of Thailand, two specimens have 25 and 36 on body; 21 and 23 on tail. Total number of bands in northern Thai forms, 33 to 40; southern Thai forms, 46 to 58.

Mr. Boo-Liat of Kuala Lumpur has reported (Malayan Nature Journal vol. 12, 1958, pp. 183-184, pl. 12) two specimens from Kedah one of the northernmost Malayan states. His figure does not show as numerous caudal spots as occurs in the southern Thai specimens.

Lycodon capucinus Boie

(Fig. 32)

Lycodon capucinus Boie, Isis, 1827, p. 551, based on Russell's Indian Serpents, vol. 2, pl. 39, (type-locality, Trivandrum India); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1136 (Rat Buri province, Thailand).

Lycodon aulicus capucinus Smith, The fauna of British India, Ceylon, Burma, including the whole of the Indo-Chinese Subregion; Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 265-266; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 131-132 (*part.*).

[Many references to *Lycodon aulicus* belong here but it is not always possible to determine which of the two forms is indicated.]

Lycodon aulicus Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, p. 16-17 (Lop Buri, Chiang Mai, Chon Buri).

The two forms presumed subspecies of *aulicus* occur together throughout much of their ranges. It seems necessary to regard them as species.

Diagnosis: Purplish to purplish brown with a reticulum of white or fawn, color confined to edges of scales and interstitial skin; snout and head rather flattened; a white band across occiput and nape, sometimes partly or completely divided mesially, the scales with lavender or purple spots; labials white with black dots; ventrals kneeled, ends turned up on ventrolateral area; loreal large, forming a suture with internasal; nine supralabials, three bordering orbit.

Description of species: (From No. 34948. Phu Kading, Loei province, Thailand): Snout flattened, projecting beyond mouth, somewhat excavated below, with a transverse blunt edge anteriorly; rostral higher than wide, bent back over tip of snout, well visible

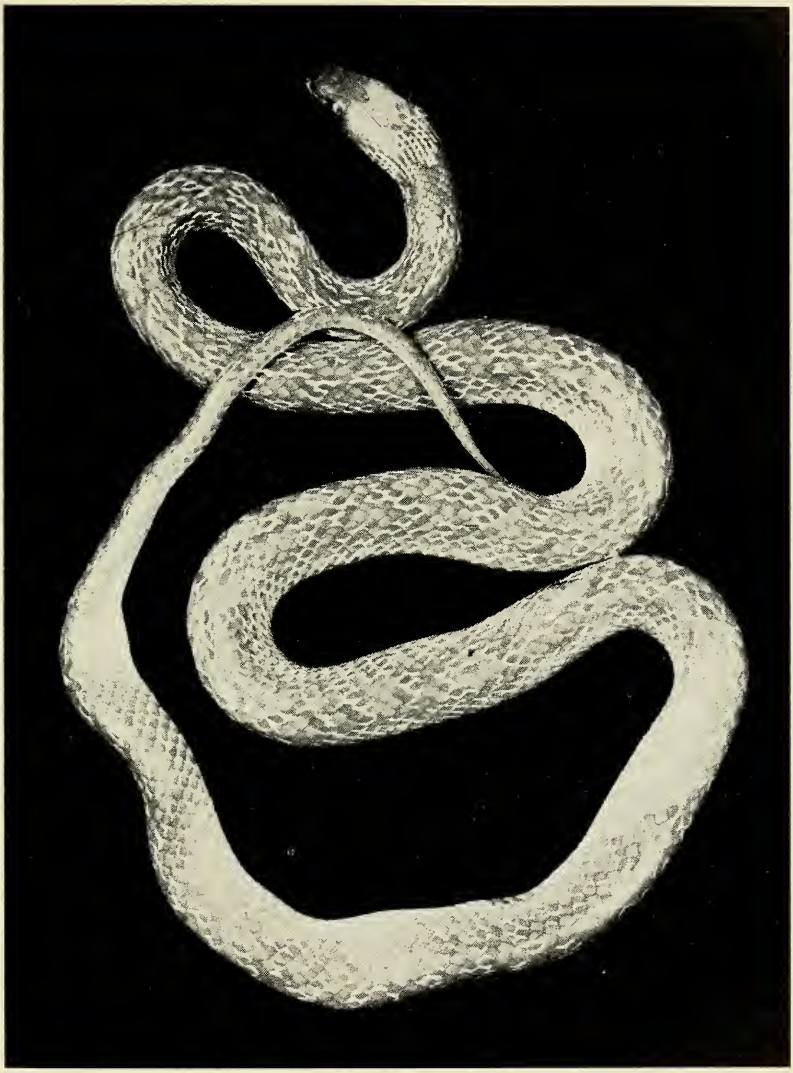

FIG. 32. *Lycodon capucinus* Boie. From Thailand. Total length, 528 mm.; tail, 93 mm.

above; internasals much smaller than prefrontals, slightly angular in front, forming a suture with loreal; prefrontals distinctly longer than wide, separated from supraocular by a minute distance; frontal slightly shorter than its distance from tip of snout, distinctly shorter than parietals; anterior nasal larger than posterior; loreal more than twice as long as high; large preocular touching frontal; two post-

oculars, each in contact with a temporal; two anterior temporals, the formula on right side $\frac{1}{1} + 2 + 3$, on left, $\frac{1}{1} + 2 + 4$; four temporals border parietals, the last separated behind parietals from its fellow by three scales; nine supralabials, third, fourth, and fifth enter eye (the third only narrowly); ten infralabials, first five touching first pair of chinshields, which are much larger than second pair.

Scales smooth, some with a minute apical pit (that can scarcely be discerned except in a transparent shed scale). Scale-formula 17-17-15. Ventrals, 205; subcaudals, 71; anals, 2; lateral keels on ventrals moderately distinct.

Color in life: Head dark purplish back to level of parietals; parietals light brownish lavender; occipital light band not divided mesially, each scale with a purplish spot; this followed by a brown band; labials all yellowish with a large purplish brown spot; body lilac to lavender-brown with a reticulum of whitish or fawn (this chiefly on scale edges and interstitial skin); tail nearly uniform brown; dirty white on venter.

Measurements and data on Lycodon capucinus

NUMBER	34948 ♀	35954	33633	No No. ♂
Total length	521	436	385	528
Tail	113	73	47	93
Head, width	10.2	9	9	10
Head, length	18	14.6	16	15.9
Ventrals	205	195	188	203
Subcaudals	71	61	67	65
Preoculars	1	1	1	1
Postoculars	2	2	2	2
Supralabials	9–9	9–9	9–9	9–9
Infralabials	10–10	10–10	10–10	10–10
Anterior nasal largest	yes	yes	yes	yes
Labials enter eye	3, 4, 5	3, 4, 5 (4, 5)	3, 4, 5	3, 4, 5

No. 34948 from Loei; 35954, 33633, Chiang Mai.

Variation: The specimens available agree in most characters. However one specimen has 19 rows of scales about neck, seventeen being the normal number. Ventrals vary in Thai specimens from 188 to 205, the subcaudals from 61-71, the higher numbers of ventrals and subcaudals being found on females.

Distribution: The species is known in Thailand from Chon Buri, Lop Buri, Rat Buri and Chiang Mai. Outside of Thailand the

species is known from India throughout southeastern Asia, Malay Peninsula, the Indo-Australian Archipelago to the Philippines and Celebes.

Remarks: The species is very domestic, being found in human habitations, especially those built with bamboo and palm leaves. It is presumed that the domestic geckoes attract these snakes since lizards form the major food of the species.

Lycodon fasciatus (Anderson)

(Fig. 33)

Ophites fasciatus Anderson, anatomical and zoological researches and zoological results of the Yunnan Expeditions. Reptilia collected on the two expeditions to western Yunnan, 1879, p. 827, pl. 78, fig. 1; (type-locality Ponsee [Pangsi] Yunnan); Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 614.

Lycodon fasciatus: Boulenger, The Fauna of British India including Ceylon and Burma, 1890, pp. 295-296; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 358; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 372; Evans, *ibid.*, vol. 30, 1925, p. 812; *ibid.*, vol. 31, 1926, p. 562; Schmidt, Bull. Amer. Mus. Nat. Hist., vol. 54, 1927, p. 523; Pope, Reptiles of China, 1935, pp. 188-191; Bourret, Le serpents de l'Indochine, 1936, p. 155; M. Smith, The fauna of British India including Ceylon and Burma, Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 266-267.

Diagnosis: A snake reaching nearly a meter in length. Black bands, wider anteriorly, separated by narrow yellowish bands that are sparsely pigmented with brown or black. Head black-brown above, lighter on temporal and occipital regions (white in young). An elongate loreal entering orbit with a small preocular above it, separating prefrontal from eye; scalerows, 17-17-15, the median five to seven or more rows keeled; ventrals feebly angulate.

Description of species: (Specimen from Doi Suthep, Chiang Mai, Thailand): Head somewhat flattened, snout projecting a little beyond mouth; temporal region somewhat swollen; rostral distinctly broader than high, portion visible above very narrow; internasals about a third of area of prefrontals, about as wide as long; prefrontals large, their common suture nearly double that between internasals; frontal a little shorter than its distance from tip of snout, very much shorter than parietals, four-fifths as wide as long; nostril between two nasals posterior much the larger with a depression behind nostril; loreal elongate more than two-and-one-half times as long as high, entering eye; a preocular separating prefrontal from eye; supraocular widened posteriorly, about half width of frontal; temporals, $2 + 2 + 2$ the upper anterior touching two postoculars; supralabials eight, third, fourth, and fifth entering orbit; nine infralabials, five touching first pair of chinshields which

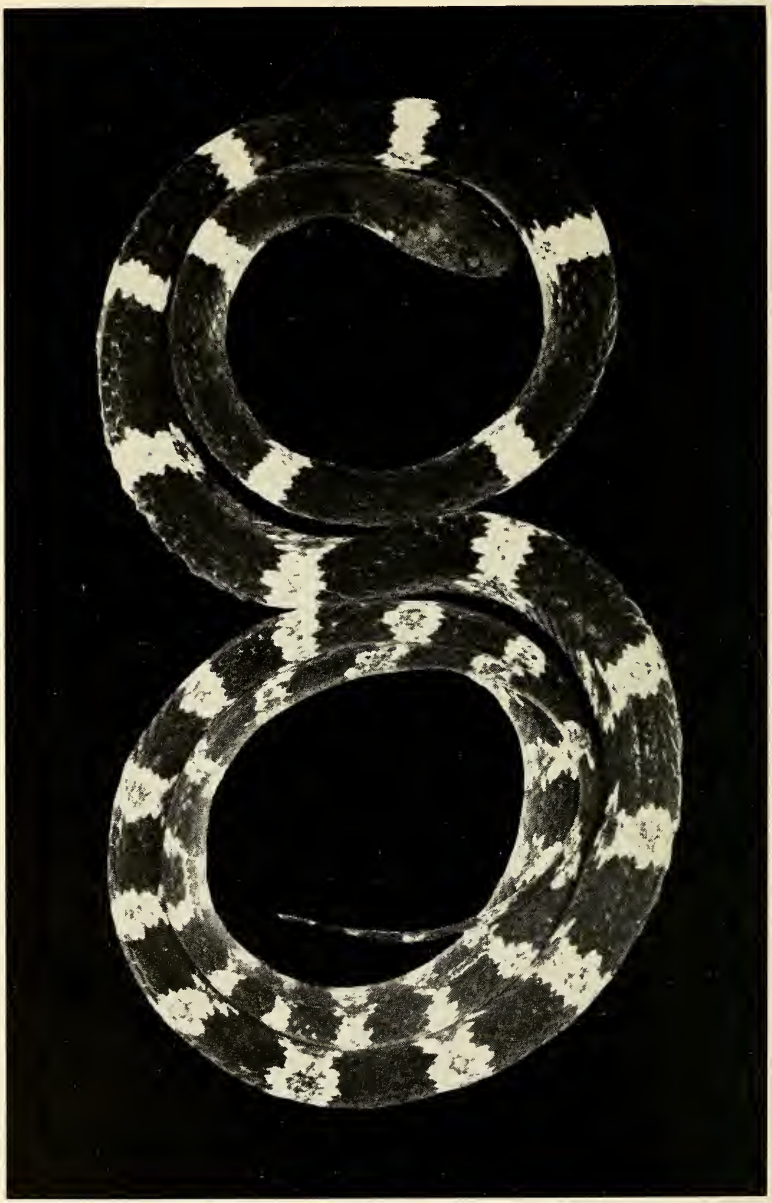

FIG. 33. *Lycodon fasciatus* (Anderson). Specimen from Doi Suthep, Chiang Mai, Thailand. Actual total length, 830 mm.; tail, 169 mm.

are a little larger than third pair; second pair very small. Scale-formula: 23 (occiput), 17, 17, 15, with small apical pits; anteriorly five median scalerows lightly keeled, while on posterior half of body seven to nine rows more distinctly keeled; opposite vent there are 13 rows strongly keeled. Ventrals, 209; subcaudals, 85; anal, single.

Color in life: Banded purplish black and cream yellow, the yellow bands two to three scale lengths in width, the edges very irregular on venter, widening so as to cover from three to five ventrals on anterior half of body, one or two on posterior part of body; scales in the yellow-cream bands pigmented more or less, often forming small spots or indefinite blotches, more strongly indicated on latter two thirds of body and tail; black bands vary in width, the nuchal band covering 18 transverse rows, and the succeeding eleven ones cover 13, 11, 10, 8, 7, 6, 6, 7, 7, 6, 5 respectively on the midline; the following 16 body bands cover between 3 and 5 transverse rows. The 13 bands on tail usually cover between three and five. Head brownish, anterior part darker than posterior; supralabials each with a dirty cream center; chin with brownish pigment, posterior infralabials cream; first seven ventrals cream.

Measurements in mm.: Total length, 830; tail, 169; snout to vent, 661; width of head, 13; length of head, 19.

Variation: The head is distinctly wider than the neck. The ventral scales are angulate laterally (but not strongly so) and the body is somewhat compressed. The tail tapers to a fine point.

A younger specimen examined has thirty dark bands on body, eighteen on the tail. On the head a dark brown mark covers the snout and the interorbital area, terminating on the anterior fourth of the parietals. The occipital and temporal regions are light brown, bordered behind by a narrow white line. A few of the bands on the anterior part of body are broken on the venter.

The squamation is as follows: supralabials, 8; infralabials, 9; there are 3-2 postoculars, the temporals, $2 + 2 + 3$, $2 + 3 + 3$. There are *three pairs of chinshields,* the first pair bordered by four infralabials, the *second, smallest* pair bordered by two, the *third pair* touching only one infralabial. There are 206 ventrals, 80 subcaudals, and the anal is single.

In the described specimen the left anterior chinshield is divided, but the middle chinshield on the right side is fused to the posterior. The color of the light bands is gray-white, the ventral coloration being somewhat cream.

The known variation in the ventrals is from 197 to 220; in the subcaudals, 69 to 94. The number of body bands varies between 28 and 49. In the very young, the back of the head is white.

Distribution: In Thailand the species has been reported from Tawkawbee, 9 mi. S. of Um Pang (lat. 16 N. long. 98° 75′ E.). Both specimens here reported are from Doi Suthep, Chiang Mai. The species extends from the eastern Himalayas, to Tibet, Burma, upper Laos, West China, and Viet Nam.

Remarks: The species is a bush snake, usually found at elevations of from 1000 to 2300 meters. The largest specimen known to me reaches a length of 934 mm.

Genus *Dinodon* Duméril and Bibron

Dinodon Duméril and Bibron, Mem. Acad. Sci. Paris, vol. 23, 1853, p. 463; Erpétologie générale . . . vol. 7, 1854, p. 447, (type of genus, *cancellatum* = *rufozonatum*).

Eumesodon Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 12, 1860, p. 262, (type of genus, *semicarinatus*).

Lepidocephalus Hallowell, Proc. Acad. Nat. Sci. Philadelphia, vol. 12, 1860, p. 498, (not of Bleeker), (type of genus, *semicarinatus*).

Adiastema Werner, Sitz. Ber. Akad. Wiss. Wien, vol. 134, p. 54, (type of genus, *cervinum*).

Lycodon Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 291 (*part.*).

Diagnosis: Head rather broad, somewhat flattened, scarcely distinct from neck; eye with a vertical pupil; scale-formula: 17, 17(19), 15; scales smooth or with indistinct keels; ventrals with or without lateral keels; scales with apical pits.

Maxillary bones extending farther forward than palatine, bent inward, with five to seven anterior teeth increasing in size posteriorly, sometimes separated from posterior teeth by a diastema; posterior teeth of first group fanglike, of second group posteriormost only slightly larger than others.

Of the nine recognized species only a single one is known to reach Thailand. It enters from the north and has been traced as far south as Chiang Mai.

It is difficult to differentiate between *Lycodon* and *Dinodon* since the differences are small. The shape of the maxillary bone and the dental characters are perhaps the most important.

The wisdom of retaining *Dinodon* as a separate genus has been questioned.

Dinodon septentrionalis septentrionalis (Günther)

Ophites septentrionalis Günther, Proc. Zool. Soc. London, 1875, p. 233 (type-locality "there is no doubt that he [Dr. Jerdon] obtained it during his last journey through the northern parts of India").

Lycodon septentrionalis Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 295 (states the length of type 83 inches (evidently a misprint) should be 33 inches).

Dinodon septentrionalis Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 363, (*part.*), and vol. 3, addenda, 1896, p. 619 (Cobapo, Karin Hills); Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 324; Journ. Bombay Nat. Hist. Soc., vol. 16, 1905, p. 235; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 778; *ibid.*, vol. 29, 1923, p. 615; Rec. Ind. Mus., 1909, p. 146; Angel, Bull. Mus. Nat. Hist. Paris, 1929, p. 79; Bourret, Serpents de l'Indo-Chine, 1936, p. 162; M. Smith, The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese Subregion; Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 270-271, fig. 91.

Diagnosis: Black with 25 to 35 narrow white or yellowish bars, becoming wider on sides; venter whitish; tail black below; 207-212 ventrals with lateral keels; 81-92 caudals; anal, single.

Description of species (composite sources): Rostral narrowly visible above, slightly angulate on median line; internasals somewhat narrowed in front; prefrontals about two and a half times size of internasals; suture between prefrontals and frontals nearly a straight line; frontal as broad as long; supraoculars slightly more than half width of frontal; parietals elongate, but length less than distance between posterior part of frontal and tip of snout. Nasal divided, posterior portion higher and larger than anterior; loreal small, narrow, separated from internasal and eye; two small postoculars; two anterior temporals followed by two posterior; lower anterior and upper posterior temporal much the largest. Eight supralabials, third, fourth, and fifth bordering orbit; seven or eight infralabials.

Scales smooth, the formula: 17, 17, 15. (One presumed subspecies may have from five to seven median rows keeled.)

Color: Purplish black above and on sides, with 25-35 narrow white transverse bars on body which may expand laterally; on forepart of body bars about twice as far apart from one another as on hinder part; venter white, sometimes spotted or barred with black, these markings being a continuation of the dark color on back; tail heavily marked with black below; posterior part of head white in young, usually black in adults.

Measurements in mm.: Total length, 1,180; tail, 190.

Distribution: The species has been found only in the northern part of Thailand in the province of Chiang Mai.

Outside of Thailand it occupies territory in the Eastern Himalayas, Assam, Burma, and Laos.

Remarks: The type of *Dinodon septentrionalis* (Günther) is said to be a snake, 83 in. (1,962 mm.) in length according to Günther.*

* Boulenger, l. c. 1893, believes this is intended for 33 inches.

There are 214 ventrals and 83 subcaudals. It is black in color, the trunk with thirty narrow white rings only two scales wide, the first at some distance behind the head. It is white on venter, the subcaudals marbled with black. Ventrals ♀ 214; subcaudals, 83.

Genus *Oligodon* (Boie *in* Boie)

Oligodon Boie *in* Boie, Isis, 1827, p. 519 (type of genus *Oligodon bitorquatus*).

Simotes (not of Fischer 1817) Duméril, Bibron and Duméril, Erpétologie général . . . vol. 7, 1854, p. 624 (type of genus, *russelli*).

Holarchus Cope, Proc. Amer. Phil. Soc., vol. 23, 1886, p. 488 (type of genus not designated).

Dicraulax, Cope, Amer. Nat., 1893, vol. 27, p. 480 (type of genus *Holarchus trinotatus* = *Simotes purpurascens.*

Malcolm Smith writes (1943, The fauna of British India, pp. 196-197): "Wall quite rightly (1923) has united *Holarchus* with *Oligodon,* the latter being only a degenerate group of the former. The passage from one to the other is gradual and no dividing line can be drawn. Degeneration has led to reduction in the number, but not always in the size, of the maxillary teeth; reduction in the number and size of the palatine teeth, but in no species are they entirely lost."

Diagnosis: Rather short medium-sized snakes rarely reaching a meter in length, while many of the species are less than half a meter. Maxillary teeth 6-16; scalerows, 13-23.

KEY TO THAI SPECIES AND SUBSPECIES OF *Oligodon*

1. Scales with paired apical pits 2
   Scales without apical pits 3
2. Scales in 17 rows at mid-body; spots on venter present or absent (two subspecies) . . . . . *cinereus*
   Scales in 15 rows at mid-body; spots absent on venter . . . . . *inornatus*
3. Scales in 21 rows at mid-body 4
   Scales in 19 rows or less at mid-body 6
4. Body with two median darker longitudinal stripes separated by a lighter median dorsal stripe; a lateral stripe to vent level; ten more or less divided dorsal dark blotches; tail long, one fifth to one sixth of total length; venter immaculate; ventral-subcaudal count high (to 229½) . . . . *dorsolateralis*
   Body without median or lateral darker longitudinal stripes; markings transverse 5
5. Series of 13-18 transverse dark spots on back and tail or spots with white or light centers, separated by ground color and three narrow irregular dark transverse lines, the dark color confined to edges of scales; venter without black quadrangular marks . . . . . *cyclurus smithi*
   No distinct spots but numerous transverse irregular lines across dorsum, the dark color confined to edges of scales . . . . . *cyclurus superfluens*
6. Scales in 19 rows 7
   Scales in 17 to 15 rows; more or less than half a meter in length 8

7. Small slender snakes with four dark longitudinal lines on body, the two median separated by a lighter line; a narrow lateral line; no spots on dorsal or caudal area..... *quadrilineatus*

   Larger snakes reaching about 90 cm. in length without longitudinal dorsal stripes but with transverse dark spots and narrow dark lines (rarely 21 scalerows)..... *p. purpurascens*

8. More than half a meter in length (to 760 mm.); scalerows 17 or 15 near mid-body; no longitudinal lines. Maxillary teeth twelve, steadily increasing in size posteriorly. Purplish-brown above with ill-defined and broken cross-bands, every alternate one enlarged. Belly red or red barred with black (in life); head markings like *cyclurus*; hemipenis like *cinereus*. *joynsoni*

   Less than half a meter in length; scales in 17 rows; longitudinal lines on body..... 9

9. Maxillary teeth 14-16; ventrals, 146-169; subcaudals, 30-47. Four dark brown or blackish longitudinal lines, two median (wide) separated by a somewhat irregular narrow light stripe (width of one scalerow); series of quadrangular spots on ends of ventrals; ventrals coral-red in life, whitish in preservative. A black spot at base of tail and one at tip (rarely absent)..... *taeniatus*

   Maxillary teeth 13-14; ventrals 135-160, subcaudals 32-44; 14 or 15 transverse, rather narrow dark dorsal spots, light-edged on body and tail (often broken in two or four separate dots) separated by three more or less distinct transverse marks, the black confined to edges of scales; a dark-edged median light longitudinal line; venter with quadrangular spots... *barroni*

Oligodon cinereus (Günther)

Simotes cinereus Günther, The reptiles of British India, 1864, p. 215 (type-locality, "Gamboja" = Cambodia).

This species, extending from the Indo-Chinese region to India and southern China, seemingly has broken up into several subspecies. At least two forms occur in Thailand, one in the northern part of Chiang Mai province, and one in the southern part of that province and in Loei province. These are *Oligodon c. swinhonis* and *Oligodon c. multifasciatus*. They may be distinguished by the following key:

KEY TO THAI SUBSPECIES OF *cinereus*

1. A well-defined narrow chevron on neck, the posterior arms extending from three to four scale-lengths posteriorly; a narrow anterior process from chevron terminates on frontal (sometimes forming two small spots); diagonal black stripe above mouth angle; and a band across snout through eyes; venter yellowish white with paired series of quadrangular dark spots on outer sides of ventrals, those bearing spots separated by one or two lacking spots; 17 scalerows at middle; ventrals 190-197; subcaudals 32-42..... *cinereus multifasciatus*

2. Dark chevron on neck dim the centers of scales involved light gray; band across snout almost or completely obsolete or a dim dark spot below eye; diagonal stripe above mouth-angle usually absent; entire chin and venter immaculate, the upturned edges of posterior ventrals with some pigment. Part of the transverse marks on body intensified somewhat, separated by three dim transverse marks, the middle one may be a little darker than other two..... *cinereus swinhonis*

Oligodon cinereus swinhonis Günther

(Fig. 34)

Oligodon swinhonis Günther, The reptiles of British India, 1864, p. 215, pl. 20, fig. E (type-locality, Amoy, China).

Simotes violaceus: Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 2, 1894, pp. 222-223 (*part.*).

Oligodon cinereus: M. Smith, The fauna of British India, Ceylon and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes. Dec. 1943, pp. 215-217 (*part.*).

Diagnosis: See key.

Description of subspecies (from No. 3464 ♀, Chiang Mai province): Rostral higher than wide, the part visible above triangular, its length greater than its distance from frontal, the scale thickened, its edges elevated on sides; internasals triangular, much narrowed posteriorly, their common suture about half as long as that between prefrontals; latter scales twice as wide as long; frontal shield-shaped about one fifth longer than wide, longer than its distance from tip of snout, shorter than parietals, less than twice as wide as supraocular; parietals sharply truncate behind, somewhat emarginate laterally; nasal divided; loreal longer than high; a single preocular, and on left side, a subocular, none on the right side; two postoculars; temporals, $2 + 2 + 3$ $(2 + 3 + 3)$; supralabials seven, (the fourth and fifth presumably fused) and only a single scale bordering orbit; infralabials nine, four touching first chin-shields which are double size of second pair.

Scale-formula: 23 (occiput), 17, 17, 15; scales smooth with distinct apical pits. Ventrals, 196; subcaudals, 42; anal, single. Tail definitely rounded above, flat below.

Color: Above generally brownish fawn to gray (dull salmon-pink in life); anteriorly outer scalerow nearly salmon-pink practically without pigment, but more posteriorly covered with gray pigment. A dark chevron on nape the posterior arms of which equal in length to three or four scales; and with a forward process reaching onto parietal suture. A faint dark mark below eye but no trace of the band through eye across snout; no diagonal marks above angle of mouth.

Edges of many scales on dorsum dark forming irregular transverse marks reaching on sides to outer scalerow. One series of about 21 transverse marks somewhat intensified, separated by three intervening bands, the median one darkest. Median scalerow on body vaguely lighter than others and on tail this line, with indefinite edges, is more distinct. Venter immaculate yellowish white

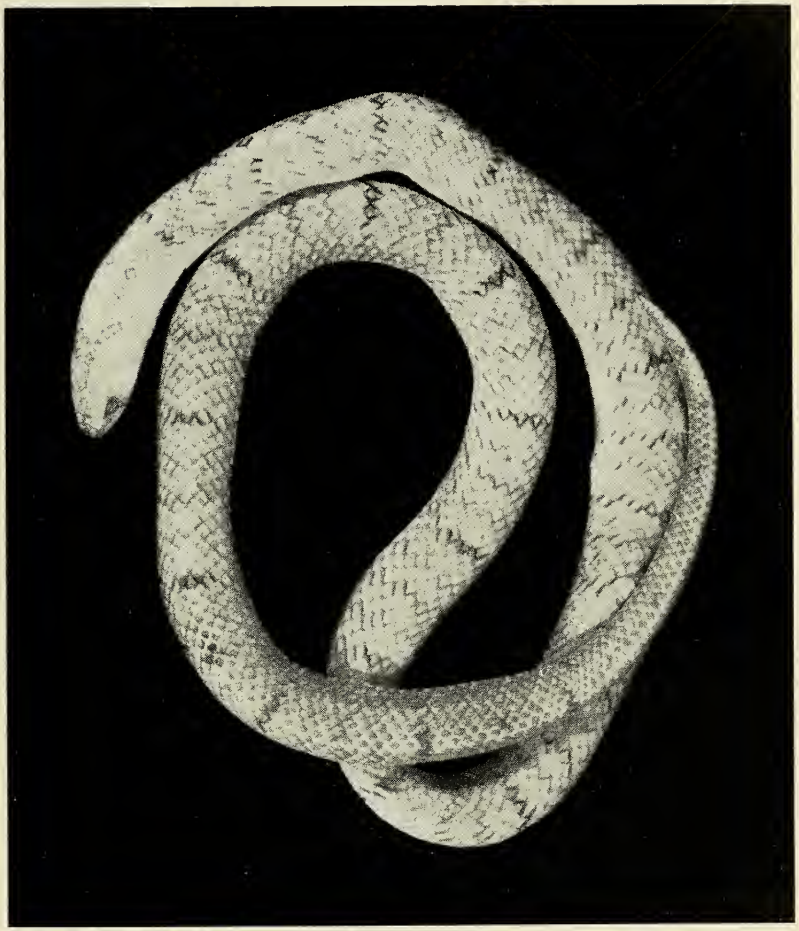

FIG. 34. *Oligodon cinereus swinhonis* Günther. No. 3464, 12 km. north of Chiang Dao, Chiang Mai province, northern Thailand. Actual total length, 632 mm.; tail, 84 mm.

to ivory lacking ventral spots of black; outermost edges of ventrals posteriorly have some pigment.

Measurements in mm.: Total length, 632; tail, 84; width of head, 14; length of head, 18.2.

Variation: The type, also a female, has 174 ventrals, and 34 subcaudals. The described specimen has considerably more than this number—196, and 42.

In Thailand this is, so far as I am aware, the only specimen that has been taken. It is presumed that it is a northern form, occuring in southern China (Amoy and westward).

Oligodon cinereus multifasciatus Jan

(Fig. 35)

Oligodon multifasciatus Jan *in* Jan and Sordelli Iconographie générale des ophidiens, vol. 1, livr. 12, pl. 5, fig. 2, (type-locality "Sultanepore").

Simotes violaceus: Boulenger, Catalogue of the snakes in the British Museum, vol. 2, pp. 222-223 (*part.*).

Oligodon cinereus: M. Smith, The fauna of British India, Ceylon and Burma . . . vol. 3, Serpentes, Dec. 1943, pp. 215-217 (*part.*).

Diagnosis: See key.

Description of subspecies (from EHT-HMS No. 3623, Chiang Mai province, Thailand): Part of rostral visible above forming a triangle, the scale thickened, slightly elevated when seen from sides; internasals much wider than long, somewhat pointed mesially; prefrontals with a median suture less than twice length of internasal suture; frontal shield-shaped, about as long as wide, shorter than its distance from tip of snout, shorter than parietals; posterior border of parietals forming a median angle. Nostril between two nasals, anterior one the larger; loreal longer than high touching two labials; a large upper preocular, and a small lower (subocular); two postoculars; temporals, $\frac{2}{1} + 2$, somewhat irregular; supralabials, 7-7 (due to apparent fusion of second and third on one side, and of fourth and fifth on other); infrabials, 8-8, four touching anterior chinshields which are more than twice as large as second pair.

Scale-formula: 21 (about occiput), 17, 17, 15 (just preceding vent). Ventrals 196; subcaudals (paired), 38; anal, single.

Color: Ground color brownish gray with black edges of many scales tending to form irregular broken transverse marks separated by one scalerow; edges of the intervening row usually cream or ivory, the color normally concealed and extending to interstitial skin. A narrow chevron on nape, its posterior arms equal in length to four or five scale-lengths; anterior median projection broken, with a round spot on parietals and one on frontal; a dim dark diagonal line above angle of mouth; a line beginning on labials passes through eye and across forehead anterior to frontal. Venter distinctly yellowish ivory with a double row of somewhat quadrangular black spots on ventrals, paired or alternating, usually separated by an unspotted ventral; chin unspotted; a few subcaudal spots; tail rounded above, flat below with an indistinct median lighter supracaudal line.

Measurements in mm.: Total length, 683; tail, 77; width of head, 13.2; length of head, 20.

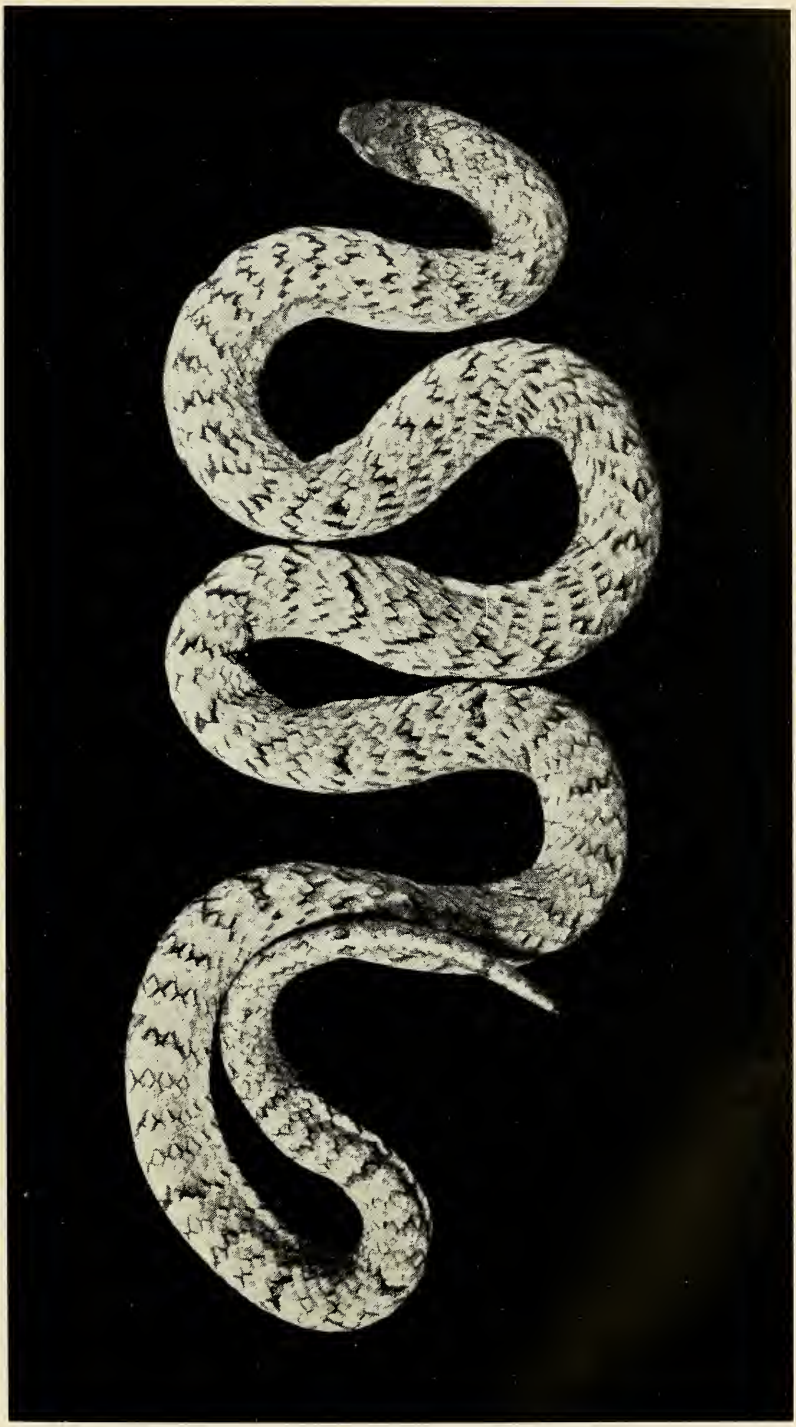

Fig. 35. *Oligodon cinereus multifasciatus* Jan. No. 3623, Chiang Dow (12 km. north), Chiang Mai province. Actual total length, 683 mm.; tail, 77 mm.

Variation: The following table shows variation in three Thai specimens:

Scale-data and measurements of *Oligodon cinereus multifasciatus*

NUMBER	Province	Ventrals	Subcaudals	Supralabials	Total length	Tail length
31699	Loei	190	32	8–7*	600	71
3623	Chiang Mai	196	38	7	683	77
28	Chiang Mai	197	42	7	90	21

* The 2nd and 3rd scales are fused on one side; there are two scales bordering orbit; the tail of No. 31699 is immaculate below.

Remarks: The form is known in Thailand from southern Chiang Mai and Loei provinces.

The type-locality is "Sultanepore," a locality unknown to me.

Oligodon inornatus (Boulenger)

Simotes inornatus Boulenger, Journ. Nat. Hist. Soc. Siam, vol. 1, pt. 1, 1914, p. 68 (type-locality, Nong Kai Ploi, E. of Sriracha, southeastern Thailand); M. Smith, *ibid.*, pp. 68-69.

Oligodon cinereus M. Smith, The fauna of British India . . . vol. 3, Serpentes, 1943, pp. 215-217 (part.).

Diagnosis: Uniform pale brown above, yellowish white beneath scales in 15 rows about body.

Description of species (from Boulenger's type-description): Nasal divided; portion of rostral seen from above as long as its distance from frontal; suture between internasals longer than that between prefrontals; frontal equal to its distance from tip of snout, and as long as parietals; two postoculars, no suboculars; temporals, 1 + 2; eight supralabials, fourth and fifth bordering orbit; four infralabials bordering anterior chinshields which are nearly twice as long as posterior.

Scales in 15 rows; ventrals, 171; anal undivided; subcaudals, 42.

Color: Uniform pale brown above, yellowish white beneath.

Measurements in mm.: Total length, 580; tail, 90.

Remarks: Published with Boulenger's paper (*loc. cit.*) was a description of a specimen of *Oligodon* by Dr. Malcolm Smith, which he regarded as a second specimen of Boulenger's *inornatus*. Smith (1943) abandoned the species placing *inornatus* as a synonym of *Oligodon cinereus* (Günther).

However there is a very strong possibility that *inornatus* is worthy recognition; and the specimen referred to it originally by Smith may require a reassignment.

Smith's statements regarding this form follow: "This snake was collected and kindly forwarded to me by Mr. P. A. R. Barron of the Borneo company, to whom I am also indebted for a second specimen, which differs from the type description in the following particulars. Position of rostral seen from above, shorter than its distance from the frontal; suture between the internasals equal to suture between the prefrontals. Loreal as long as deep. Ventrals 174. Subcaudals 40. Color. Above, dull, salmon red (much brighter I am informed in life) and with very faintly marked dark greyish narrow cross-bars. Below, with indistinct, small squarish spots, placed laterally, in the posterior half of the body and tail. This specimen has been in my possession for some months, and the handsome red coloring has gradually faded until now it is nearly of the brown hue described by Mr. Boulenger. Mr. Barron who saw both specimens when fresh informs me, however, that the first one never showed any red coloration."

The type locality of *inornatus* is Nong Kai Ploi, East of Sriracha, Chon Buri. Boulenger regarded the species as being related to *violaceus*. M. Smith (1943) remarks that, "Specimens from the extreme south-eastern corner of Siam (south of Retriu) and eastwards to the adjacent territory of Cambodia, have only 15 scale rows at mid-body."

Oligodon dorsolateralis Wall

Simotes albocinctus dorsolateralis Wall, Journ. Bombay Nat. Hist. Soc., vol. 19, p. 898 (type-locality Jalpaiguri District, no type designated).

Oligodon cyclurus: M. Smith, The fauna of British India, Ceylon and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes. Dec. 1943, pp. 202-206 (*part.* var. IV.)

Diagnosis: Scales in 21 rows, with four longitudinal stripes, the two median extending to tail, the two lateral to level of vent; ten more or less divided dorsal blotches, four on tail. Tail long, between one fifth and one sixth of body length; venter immaculate, occasionally spotted (in Burmese specimens).

Description of species (from No. 77 ♂): Rostral about as high as wide, the triangular part visible above, distinctly shorter than its distance from frontal, thickened as seen from sides; internasals rather angular on anterior edge, much wider than long, somewhat

obliquely placed, prefrontals nearly twice as wide as long, their common suture equal to that between internasals; frontal slightly longer than its distance from tip of snout, as long as parietals; latter nearly as broad as long; nasal divided, anterior part largest; loreal quadrangular, higher than long; two preoculars, or one preocular and one subocular, latter lying below level of eye between third and fourth labials; two postoculars, both touching first temporal; temporal formula, 1 + 2 + 3, somewhat irregular (one might regard the arrangement as two anterior temporals the lower largest and separated from both postoculars by the upper); eight supralabials, fourth and fifth bordering orbit; nine infralabials, four touching anterior chinshields which are somewhat more than twice size of second pair.

Scale-formula: 24 (occiput), 19, 21, 17; ventrals, 176½; anal, single; subcaudals, 53. Body somewhat angular ventrally; tail distinctly triangular in cross-section and somewhat stiffened, ending in a semirigid point.

Color in life: Above light brown with a pair of median stripes, each covering two scalerows and part of a third, posteriorly separated by a light median stripe covering all of one scalerow; posteriorly stripes extending to tip of tail, anteriorly joining a chevron-shaped mark that terminates at middle of frontal; two oblique temporal marks cross angle of mouth, passing slightly beyond; a wide dark mark on snout reaching from back part of frontal to rostral, laterally crossing eye to upper part of fifth labial; a lateral stripe on edges of fourth and fifth scalerows, reaching to level of vent; ten dorsal blotches mesially divided and more or less confluent with small lateral spots on lateral stripe; below on chin and venter immaculate ivory; ventrals upturned laterally, the upper edges with some grayish pigment similar to adjoining scalerows. Tail with four dorsal spots.

Measurements in mm.: Total length, 607; tail, 105; width of head, 13; length of head, 20.

Variation: The specimen described is from the city of Chiang Mai. I first saw the specimen from a hospital window in the yard and captured it.

The species originally described by Wall, was placed as a subspecies of *albocinctus;* Malcolm Smith regards it as a form of *cyclura.* As another subspecies of *cyclura* occurs here it seems best to regard this as a distinct species.

Distribution: This form is known only from this locality in Thailand. Elsewhere it occurs in Burma and Assam or near the Assam-Bengal boundary.

Oligodon cyclurus (Cantor)

Coronella cyclura Cantor, Proc. Zool. Soc. London, 1839, p. 50, (no type-locality known, the type lost. A colored drawing signed by Cantor exists.)

Simotes cyclurus: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 311; Catalogue of the snakes in the British Museum, vol. 2, 1894, pp. 219-220; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, pp. 324-325; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 97, fig.; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 780.

Holarchus purpurascens: Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, pp. 27-28 (Bangkok).

Holarchus cyclurus: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 14, 1920, p. 96.

Oligodon purpurascens: (*non* Schlegel) Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 631; *ibid.*, vol. 30, 1925, p. 815; *ibid.*, vol. 31, 1926, p. 563; Rec. Ind. Mus., vol. 35, 1923, p. 328; *ibid.*, vol. 25, 1923, p. 328; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 53-55.

Simotes fasciolatus Günther, The reptiles of British India, 1864, p. 218, pl. 20, fig. B (type-locality "Petchabun" southeast Siam (possibly Phet Buri (Petchaburi) SW Thailand at the upper end of the peninsula).

Simotes smithi Werner, Sitz. Ber. Akad. Wiss. Wien, vol. 134, 1925, p. 58 (Siam); M. Smith, Ann. Mag. Nat. Hist., ser. 10, vol. 1, 1928, p. 497.

Coronella violacea Cantor, Proc. Zool. Soc. London. 1839, p. 50, (type-locality Rangpur, Bengal).

Oligodon cyclurus: Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Dec. 1943, pp. 202-205, figs. 62-63 (*part.*); Taylor and Elbel Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1136-1137 (Chaiyaphum, Loei and Nakhon Phanom provinces).

Diagnosis: A rather large species of the genus reaching a length of 940 mm. variable, producing a variety of forms that should be treated as subspecies; scale formula, 21, 21, 17.

Oligodon cyclurus smithi (Werner)

(Fig. 36)

Simotes smithi Werner, Sitz. Ber. Akad. Wiss. Wien, vol. 134, 1925, p. 58, (type-locality, "Don-Rek," Siam, presumably the Dong Rek mountains between Thailand and northern Cambodia.)

Oligodon cyclurus: M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 202-204, fig. 62; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1136-1138, fig. 25.

Holarchus purpurascens: Cochran, Proc. U. S. Nat. Mus., vol. 77, (2) 1930, p. 27.

Diagnosis: Brownish or yellowish brown with 15-17 black or brown spots edged with darker color, each spot separated by three narrow irregular black transverse marks, the color broken and confined to edges of scales. A strong chevron on neck extending to frontal, its posterior branches reaching about to level of 10th

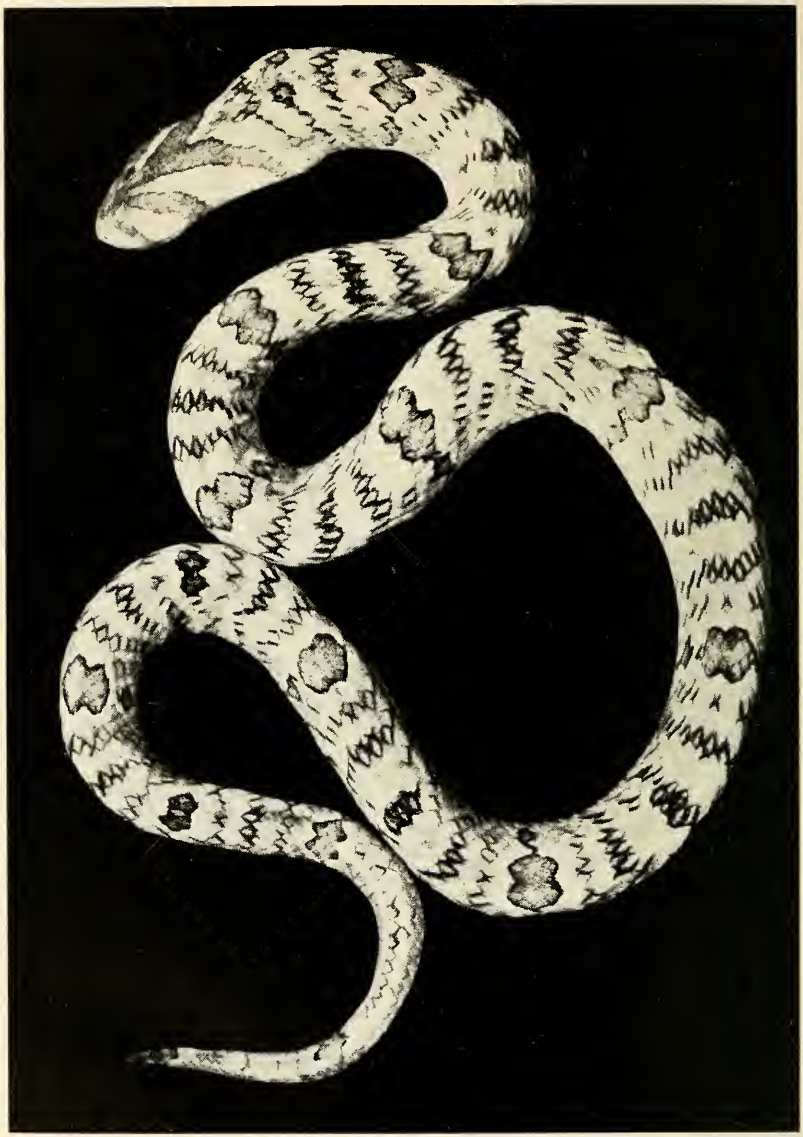

FIG. 36. *Oligodon cyclurus smithi* (Werner). EHT-HMS No. 31701 ♂, Kho (Mt.) Kanbuang, Nakae district, Nakhon Phanom province, Thailand. Actual total length, 579 mm.

ventral; a mark across snout and a stripe from occiput across jaw-angle; venter immaculate.

Description of species (from No. 33569, Ang Hin, Chon Buri): Rostral considerably wider than high, thickened and bent back

over tip of snout, portion visible above triangular, its length distinctly greater than its distance from frontal; internasals diagonally placed, their mutual suture about one fourth of their diagonal length (width); prefrontals likewise narrowed greatly on mid-line their mutual suture about a fourth of the width of scale; frontal about one sixth longer than wide, its length equal to its distance from end of snout and equally as long as parietals; parietals as wide as long; nasal divided, anterior part the larger; loreal about as high as long; two preoculars, lower small, between third labial and eye; two postoculars; temporals, 2 + 2 + 3 on right side (irregular on left side); supralabials, eight, fourth and fifth border orbit, last two largest; greatest diameter of eye much less than its distance from lip, less than its distance to nostril. Mental tiny; nine infralabials; first pair of chinshields twice as large as second, bordered by four infralabials.

Scale-formula: 24 (occiput), 17, 17, 15; ventrals, 162; subcaudals, 49; anal, undivided.

Color: Above gray-brown; body with 13 or 14 somewhat faded spots on body; spots on tail obsolete; between spots three narrow dark transverse bars; black color not reaching below second scale-row; venter immaculate; nape with a large chevron-shaped mark terminating on frontal, its posterior branches terminating at level of eighth ventral; a diagonal bar from parietal across jaw-angle; a band across snout widened mesially passing back and down through eye and across fourth and fifth labials.

Measurements in mm.: Total length, 695; tail, 124; width of head, 18; length of head, 22.

Variation: No. 32043 is a light fawn-colored specimen bearing a series of black spots with white centers, the outer portion of the spots detached and forming a second row of smaller spots on each side, likewise ocellated. The outer rows and entire ventral surfaces immaculate. There are eleven spots on body and four on the tail. The tail is distinctly triangular in cross-section and terminates in a stiff spine. The ventrals are 169; subcaudals 53; scalerows 21.

Variation in ventral scale-count, in material at hand, is 161 to 185; subcaudals, 42 to 56. Most male specimens have the tail stiffened. All (except one specimen with 19), have 21 rows of scales about the middle of the body.

Distribution: This is one of the commoner snakes of Thailand. It has been found in the following provinces: Chaiyaphum, Loei, Sara Buri, Chon Buri, Nakhon Phanom, and Sakon Nakhon. It

probably occurs widely in the plateau areas and the lowlands of central, eastern and southeastern Thailand. It has been taken in Bangkok and the northern part of the peninsula.

Remarks: I have found these snakes very unpleasant to handle as they bite readily. Even when the head is held in the hand the serpent has a propensity of pushing out the back part of the maxillary sidewise and biting, the posterior teeth being the ones that seem to cut the flesh to produce much bleeding.

Malcolm Smith remarks that "In disposition most of the species (of *Oligodon*) are quiet and inoffensive. *O. cyclurus* however, in my experience, is a most vicious creature."

Oligodon cyclurus superfluens subsp. nov.

(Fig. 37)

Type: No. 77, ♂ Doi Suthep, near Chiang Mai (city) at low elevation (150m.); Edward H. Taylor, Coll., Sept. 6, 1959.

Diagnosis: A large series of tiny black marks on edges of dorsal scales (usually not more than two edges of a scale dark) the marks tending to form series of transverse, sometimes angular marks, the angles directed forwards, then laterally they may form a second angle. One or two alternating scalerows may have scales edged with cream or yellow-cream, the color extending on interstitial skin. Head markings similar to *cyclurus cyclurus;* venter immaculate. Scalerows, 21 at middle; ventrals, 179, subcaudals, 47; head wide; tail rigid ending in a sharp point.

Description of type: Rostral somewhat thickened, about as high as wide; portion visable above triangular, its length above, at least as long as its distance from frontal, and tending to displace internasals to a somewhat oblique position; suture between internasals a little shorter than that between prefrontals; latter scales about twice as wide as long; frontal pentagonal; shorter than its distance from tip of snout, shorter than parietals; nasal divided, anterior part the larger; loreal quadrangular, higher than wide; two preoculars, lower (subocular) between third and fourth supralabials; two postoculars, temporals, 2 + 2 + 3, upper anterior touching both postoculars, lower anterior separated from them; supralabials eight, fourth and fifth entering orbit; nine infralabials, four touching first chinshields which are one-and-three-fourths times size of second pair.

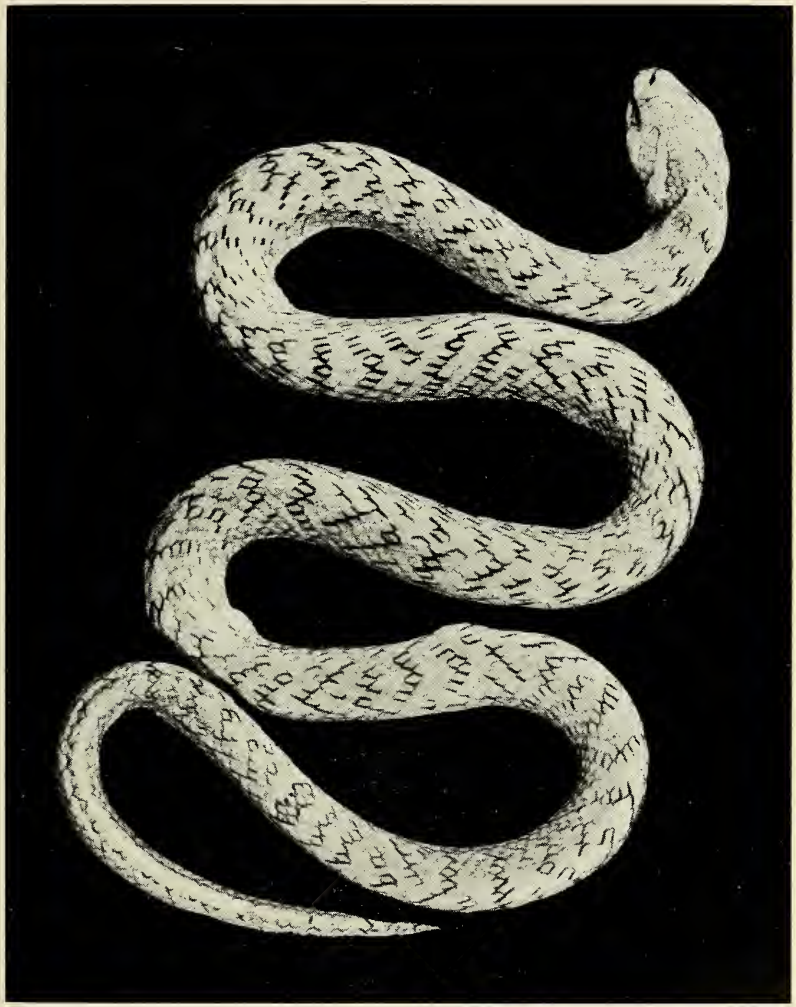

FIG. 37. *Oligodon cyclurus superfluens* subsp. nov. Type. No. 4, Doi Suthep (at low elevation, near base), Chiang Mai, Chiang Mai province, northern Thailand. Actual total length, 603 mm.; tail, 90 mm.

Scales smooth, the scalerows: 21, 21, 17; ventrals, 179; anal, single; subcaudals, 47. Tail triangular in cross-section.

Color in life: Above general body color light brownish gray with a series of about 70 transverse black marks made up of the black edges of scales; many marks are angular mesially, the angle directed backwards, the black marks not passing below second scalerows. Top of head, a little darker than on sides.

A long chevron-shaped mark on nape, its rounded apex terminating on frontal, its posterior branches reaching back to level of ninth ventral scale; two oblique bars across snout extending from front edge of frontal to rostral, narrowing, passing through eye to mouth and crossing fifth and sixth supralabials; no black marks on following labials; many transverse scalerows without black edges, but with cream marks instead, also confined to scale-edges, but extending onto interstitial skin. Towards posterior part of body a suggestion of a median whitish streak beginning at level of vent, terminating on the sharp-pointed, semi-rigid tail; sides of tail largely unicolored, with a dorsolateral trace of black marking on a slightly darker ground color; a small dark dorsal blotch an inch in front of vent level.

Measurements: Total length, 603, tail, 90; width of head, 16, length of head, 214.

Remarks: This species bears a remarkable superficial resemblance to *Oligodon cinereus multifasciata* that occurs in the same locality. There is however in this form an immaculate venter. The head-markings are wider and more strongly defined such as is typical of those in *cyclurus*. The tail is proportionally longer, triangular in cross-section, not rounded above and flat below.

Oligodon purpurascens purpurascens (Schlegel)

(Fig. 38)

Xenodon purpurascens Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 90, pl. 3, fig. 13, 14 (type-locality, Java?).

Simotes purpurascens: Boulenger, Catalogue of the snakes in the British Museum, vol. 2, pp. 218-219 (*part.*); A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 148-149.

Diagnosis: Rostral not distinctly thickened, length of part visible above less than its distance from frontal; scales in 19 rows (21); below many ventrals have quadrangular dark spots usually alternating with ventral having no spots; subcaudals numerous, 53-56 in peninsular specimens.

There are certain populations of *purpurascens* worthy of subspecific designation. Several of these have been named, but a revision of the genus will be necessary to bring about a proper understanding of the group as a whole.

Description of species (from No. 3894 Na Pradoo, Pattani, Thailand): Rostral not or scarcely thickened, not or scarcely higher than wide; part visible above triangular, its length less than its distance from frontal; internasals about twice as wide as long,

FIG. 38. *Oligodon purpurascens purpurascens* (Schlegel). No. 3894, Na Pradoo, Pattani province, Southern Thailand. Actual total length, 222 mm.; tail, 38 mm.

somewhat diagonally placed, their mutual suture a little longer than that between prefrontals; frontal much longer than wide (3.5 x 5 mm.), a third longer than its distance to tip of snout, longer than parietals; parietals a little longer than wide; anterior nasal larger than posterior; loreal higher than wide; one preocular and a very small subocular; supraocular about half greatest width of frontal; two postoculars; temporals, $2 + \frac{1}{1+1}$; eight supralabials, fourth and fifth bordering orbit of eye; mental narrower than rostral; 8-9 infralabials, 3-4 touching first chinshields which are more than double size of second pair; latter separated from first widened ventral by a single pair of scales.

Scale formula: 22 (occiput), 19, 19, 15; ventrals, 173; subcaudals, 56; anal, single.

Color: Above light gray-cream with a series of 19 transverse spots, (four confined to tail), the spots widening in two places dorsally, much narrower laterally and edged with black, separated from each other by an area of ground color with three thin transverse dark lines; a row of somewhat quadrangular brown spots on outer part of ventrals and subcaudals, except on neck and posterior part of tail; two ventrals with brown spots alternating with two lacking spots, or each alternate ventral bearing a spot; a curving band of brown on snout passing through eye onto fifth and sixth labials; a large arrow-shaped dark mark on nape bordered with deep brown or black, terminating on middle of frontal, deeply emarginate behind, the posterior parts terminating on each side on outer scalerow at level of ninth ventral; diagonal line from parietal across jaw-angle barely indicated; venter ivory; some small marks on tip of snout below.

Measurements in mm.: Total length, 222; tail, 38; width of head, 9; length of head, 12.2.

Variation: Boulenger (A vertebrate fauna of the Malay Penin. 1912) gives the variation in ventrals as 160 to 210; subcaudals, 40 to 60. There may be two suboculars and two preoculars; at middle of body scales are in 19 (21) rows.

Distribution: The described specimen represents the first one reported in Thai territory. It was collected by Nai Prayoon Kananuracks. Outside of Thailand it occurs in Malaya, Singapore and in many islands of the Indo-Australian Archipelago.

Remarks: Mr. Tweedie (1954) makes the following comments on the coloration in life of the young and adults: "Brown or purplish above with black-edged darker cross-bars which are broadest dorsally and may have their margins wavy; between these broad cross-bars other ill-defined narrower ones are usually present. Under surface pink or yellow with square dark spots on the ends of alternate, or more widely separated, ventrals." . . . "The whole colour pattern becomes gradually more obscure with age, but the young are quite brilliantly coloured, the ground being light brown with scattered red spots, the main cross-bars wholly black, and the underside coral pink."

He states that the scales are in 19 or 21 rows and that the serpent reaches a length of about three feet. It is quite common in wooded country.

Oligodon quadrilineatus (Jan)

(Fig. 39)

Simotes quadrilineatus Jan, Nouv. Arch. Mus. Paris, vol. 2, p. 7; Jan and Sordelli Iconographie général des ofidiens, tome. 1, livr. 12, 1865, pl. 4, fig. 3 (type-locality, Siam).

Simotes taeniatus: Boulenger, Catalogue of the snakes in the British Museum, 2nd ed., vol. 2, 1894, pp. 227-228 (*part.*); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 2, 1914, pp. 98-99.

Holarchus taeniatus taeniatus: Cochran, Proc. U. S. Nat. Mus. vol. 77, 1930, p. 28 (Bangkok, Nonthaburi, Korat, Pak Jong, Nong Mong).

Oligodon quadrilineatus: M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, sec. 1943, p. 210; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1140-1142, fig. 27.

Diagnosis: Two dorsal and two lateral brown stripes; dorsal lines separated by a lighter, partly yellow line; scale-formula: 19, 19, 15; no black stripe crossing rostral; four anterior labials on each side; no black spot at base of tail or near tip; a blackish chevron on nape and two oblique temporal marks; a wide black mark on snout, narrowing and crossing eyes to lip; reddish on venter.

Description of species (from No. 667 Bangkok): Rostral a little higher than wide, triangular part visible above as long as internasals; latter angular anteriorly, wider than long, their common suture about two thirds as long as that between prefrontals; latter scales one-and-a-half times as wide as long, their suture with frontal forming a straight line; frontal longer than its distance from tip of snout, only slightly shorter than parietals; nasal divided, anterior part much the larger; loreal longer than high; one preocular, two postoculars; temporals, $1 + 1 + \frac{1}{2}$, eight supralabials, fourth borders orbit, sixth and seventh largest; nine infralabials, four bordering first chinshields which are twice size of second.

Scale-formula: 22 (occiput), 19, 19, 15; scales smooth without apical pits. Ventrals, 157; subcaudals, 41; anal, single.

Color in life: Body and head gray with two longitudinal median dorsal blackish stripes to tip of tail, separated by a narrow yellowish-white line passing through median scalerow, but not covering whole scales. Edges of the brown scales yellow, as is also interstitial skin; a lateral line on fourth and fifth scalerows terminating at level of vent; head with a transverse mark crossing frontal and back part of prefrontals, passing through eye and across fifth and sixth supralabials; a spot on frontal; two diagonal temporal stripes arising at edge

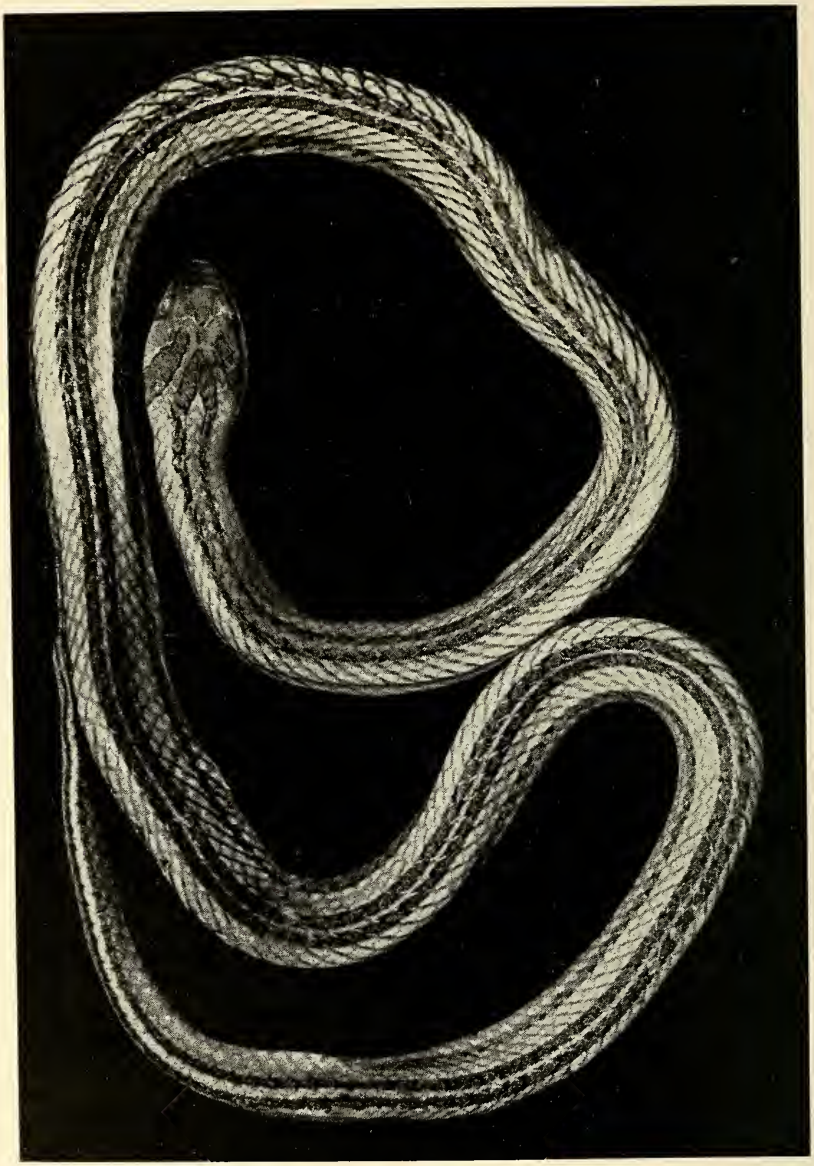

FIG. 39. *Oligodon quadrilineatus* Jan. KUMNH No. 31437, Banlat Ban Kaeng, Phukheio, Chaiyaphum province, Thailand. Actual total length, 354 mm.

of supraoculars and terminating on sides of neck; an arrow-shaped mark on neck, terminating on back of parietals connected behind with two dorsal stripes. Venter laterally angulate but bluntly so; lateral part of ventrals cream or ivory; chin and throat dirty ivory, gradually growing pink, then reddish to near tip of tail, with numerous ventrals bearing more or less quadrangular spots, forming two rows, the spots sometimes alternating, sometimes on the same ventral (rarely connected) and usually separated by a ventral lacking spots; ventral part of the tip of tail white. Most gray scales of body, under a lens, show some black along scale edges and on the interstitial skin.

Table of data on *Oligodon quadrilineatus* (Jan)

NUMBER	667	672	34166	34168	34169
Total length	375	375	388	402	342
Tail	63	64.5	67	66	62
Anal	1	16	1	1	1
Ventrals	157	15	159	157	157
Subcaudals	41	44	43	43	44
Supralabials	8–8	8–8	8–8	8–8	8–8
Infralabials	9–9	9–9	9–9	9–9	9–9
Preocular	1–1	1–1	1–1	1–1	1–1
Postoculars	2–2	2–2	2–2	2–2	2–2
Temporals	1+1+½	1+1+½	1+1+½	1+1+½	1+1+½
Scale-formula	19, 19, 15	19, 19, 15	19, 19, 15	19, 19, 15	19, 19, 15

Distribution: This species is found commonly at Bangkok in central Thailand. Specimens are known from Chaiyaphum, Nakhon Ratchasima and Sara Buri. It is presumably endemic in Thailand.

Remarks: The species apparently, in the region of Bangkok maintains its identity although the closely related *taeniatus* occurs also. They are both small forms, having a reddish venter with quadrangular spots. The latter species differs in the number of scale-rows at the middle of body (19 instead of 17), there are no large blotches on the tail, no black band bordering the front of the upper lip, and the bar on the snout is much narrower.

There is some confusion in the literature. Günther's original description of *taeniatus* stated there were 19 scale rows, but later this was corrected to 17. Boulenger, 1914 (p. 70) has overlooked the correction and proposes a new name needlessly.

The specimens listed in the table are from Bangkok.

Oligodon barroni (Smith)

(Figs. 40, 41)

Simotes barroni M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, No. 1, 1916, pp. 46-47, pl. —, fig. 4, 4a (type-locality, Hup Bon, E. of Sriracha, Chon Buri province, Thailand).

Holarchus taeniatus candaensis Bourret, Bull. Gen. Instr. Pub. Hanoi, May 1934, p. 173 (type-locality, Canda, near Nhatrang, S. Annam (*fide* M. Smith).

Oligodon barroni: M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 210-211, fig. 66 (dorsal pattern).

Diagnosis: A small species (380 mm.) with 10-12 dark-brown transverse ventral bars tending to be confluent with small lateral brown spots; these separated by three more or less distinct dark narrow transverse markings. Near outer part of ventrals a light

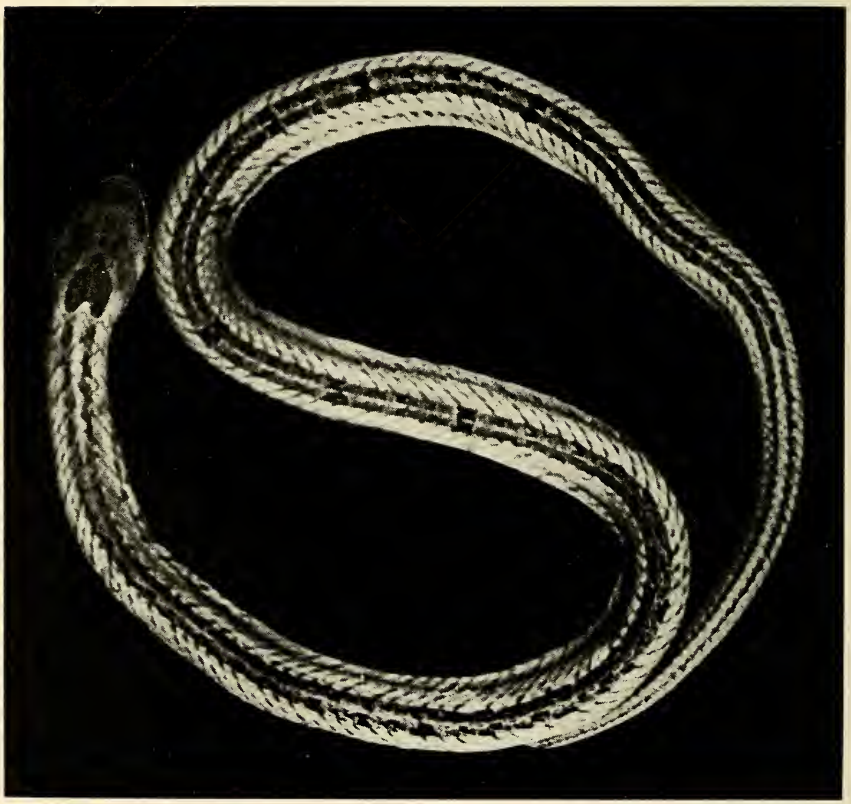

FIG. 40. *Oligodon barroni* M. Smith. No. 1719 young, Muak Lek, Friendship Highway, Sara Buri, province, Central Thailand. Actual total length, 222 mm.; tail, 36.3 mm.

line, with two ventral rows of quadrangular black spots. A broad, somewhat heart-shaped nuchal spot with a forward arm; a diagonal stripe across angle of mouth closely approximating nuchal spot, all more or less outlined with gray white; a faint pair of dorsal brownish lines with irregular spotting, and a faint lateral line, at least posteriorly; one anterior temporal; seven (eight) supralabials, two bordering orbit; 135-160 ventrals; venter coral-red, fading to white in preservative.

Description of species (from No. 33245 Ang Hin, Chon Buri): Rostral as high as wide, not thickened, well visible above, angular mesially; internasals wider than long, their common suture less

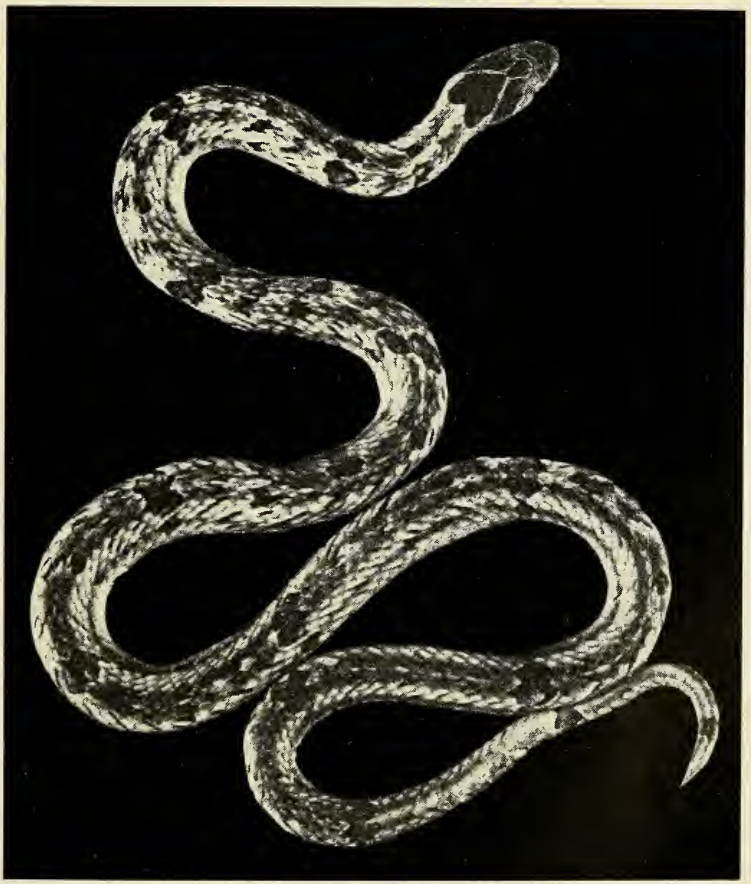

FIG. 41. *Oligodon barroni* M. Smith. No. 34149 ♂, Ang Hin, Chon Buri province, southeastern Thailand. Actual total length, 372 mm.; tail, 54 mm.

than one half their width; prefrontals about twice as wide as long; frontal pentagonal, front edge a straight line, sides not parallel, its length equal or slightly greater than its distance from tip of snout, shorter than parietals; nasal divided, anterior part a little larger than posterior; loreal quadrangular, longer than high; preocular narrowed above not reaching top of head; two subequal postoculars; temporals, $1+\frac{1}{3}$; supralabials, 7-8, third and fourth (fourth and fifth) entering orbit; infralabials, 9-9, four in contact with first chinshields which are nearly double size of second pair.

Scales smooth, the formula: 17, 17, 15; ventrals, 152, anal, single, subcaudals, 46; ventrals angular laterally their outer parts turned up on sides.

Color in life: Above generally light brown with a faint trace of two dorsal stripes of darker brown and a still fainter lateral stripe; head with a dark brown transverse crescent across frontal-prefrontal area passing across eyes to terminate on fifth (sixth) labials; a small dark spot on the following labial; a diagonal stripe from parietal to third ventral; a heart-shaped nuchal spot, its apex on posterior part of parietals; all head-spots edged with gray-white; on body eleven rather distinct dark brown bars, often confluent with a lateral series of smaller spots, and mesially indented, in some cases dividing the spot; between these median spots three more or less definite narrow transverse marks; tail with four transverse bars, but intervening marks absent; chin whitish; venter pink to coral red with two rows of brown quadrangular marks, extending on to subcaudal region almost to tip of tail; rostral gray-white with two small dark vertical marks.

Measurements in mm.: Total length, 364; tail, 70.5; width of head, 8; length of head, 13.

Distribution: Only a few specimens of this species have been taken. Malcolm Smith who described the form in 1916 had three specimens from Hup Bon, Sriracha, Chon Buri. It has been taken on the island Koh Lam near Sriracha, and at Muak Lek altitude 199 ft. in Sari Buri province. My two specimens are from Ang Hin, Chon Buri. A third specimen in the collection is possibly also from this place.

Variation: The number of labials is variable. Smith reports three having seven on one side, eight on the other, while a single specimen has eight on each side. He reports one specimen lacking the

larger dark spots on the anterior part of the body. In the specimen I figure, the three anterior dark spots are scarcely larger than the intervening marks.

A young specimen from Muak Lek, has a count of 160 ventrals.

The dorsal brownish stripes are not mentioned in the type description. However the excellent figures show these as well as an indistinct lateral line.

Oligodon taeniatus (Günther)

Simotes taeniatus Günther, Proc. Zool. Soc. London, 1861, p. 189; The reptiles of British India,* 1864, p. 216, pl. 20, fig. A (type-locality, Cambodia); Boulenger, Catalogue of the snakes in the British Museum, 2nd. ed.; vol. 2, 1894, pp. 227-228 (*part.*); Boettger, Ber. Senckenb. Nat. Ges., 1894, p. 134, (*part.* states that *taeniatus* = *quadrilineatus*); Barbour, Proc. New England Zool. Club, vol. 4, 1909, p. 70; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, p. 98 (Bangkok).

Simotes taeniatus mouhoti Boulenger, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 70 (type-locality, "Gamboja" = Cambodia).

Holarchus taeniatus mouhoti: Cochran, Proc. U. S. Mus., vol. 77, 1930, p. 29; Bourret, Les Serpents de l'Indochine, 1936, p. 247.

Oligodon taeniatus M. Smith, The Fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, p. 208-210, figs. 64, A and B; fig. 65.

Diagnosis: A small species with a very broad band across snout, narrowing across eyes and labials; an elongate frontal spot extending onto parietals; two oblique temporal stripes reaching down onto ventrals; a symmetrical blotch on nape reaching back of parietals; reddish below except on chin and neck; numerous quadrangular black spots on venter some fusing and making bars, not arranged in rows; a median dorsal yellowish line; two dorsal darker stripes extending to tail and a lateral stripe stopping at level of vent; a spot at base and one near tip of tail; a continuous black band across anterior labials and rostral; two preoculars; eight supralabials; 17 scalerows.

Description of species (from No. 609, Hua Hin, Prachuap Khiri Khan): Rostral as high as broad, the part visible above equal to about half its distance from frontal; internasals somewhat angular anteriorly a little wider than long; prefrontals about twice as wide as long; frontal subpentagonal longer than its distance from tip of snout, a little shorter than combined parietals; nasal divided, anterior part the larger; loreal quadrangular longer than high; two preoculars, lower small, partly between third and fourth

* The original description states 19 scale rows. In the second report Günther corrects this to 17 scalerows.

supralabials; two postoculars; first temporal small, touching both postoculars; temporal formula, $1+1+\frac{1}{2}$; eight supralabials, fourth and fifth bordering orbit, last four large; eight-nine supralabials, four bordering first chinshields which are a little less than twice size of second pair; scales smooth in 17, 17, 15 rows, without pits; ventrals, 148; subcaudals, 43; anal, single.

Color in life: Grayish above with two light-brown median stripes covering little more than one scalerow, separated by a narrow lighter line, the scales of which have yellow spots or edges, and much of the skin between scales also yellow. Head, anteriorly with a broad band across snout, narrowing across eyes, and extending posteriorly across three supralabials; anterior supralabials white with a band beginning on rostral extending along lip to fifth labial but not onto it; an oblique temporal band extending from parietals under neck onto ventrals, but not forming a connection; a symmetrical black blotch on neck terminating on back of parietals; an elongate spot on frontal; all head-marks outlined in whitish; venter generally pink with quadrangular spots, few anteriorly and practically none on latter part of tail, some spots joining to form bars on venter; chin ivory-white.

Measurements in mm. (of Nos. 608 ♂, 609 ♀): snout to vent, 212, 184; tail, 38, 22.5; width of head, 6, 5.8; length of head, 10, 9.8.

Variation: The second specimen measured is a young female. The ventrals are 157, the subcaudals, 32. The tail is complete. In color and general squamation the two specimens agree almost perfectly. They are from the same locality.

Malcolm Smith, *loc. cit.* records the total length of one male specimen as 340 mm.; the tail 60 mm. A second female specimen as 330 mm. the tail 45. The variation in ventrals is 146 to 169; in subcaudals, 30 to 47.

Distribution: The species is not uncommon at Bangkok where it occurs with *Oligodon quadrilineatus.* Specimens have also been taken in "Siam between lat. 12° and 16° N"; Prachuap Khiri Khan. Outside of Thailand the species is known in Cambodia and Cochin China.

Remarks: My specimens were found under piles of recently cut grass on the golf course at Hua Hin.

Addenda: Malcolm Smith, *loc. cit.*, 1943 gives the range of this species in Thailand as "Siam between lat. 12° and 16° N." Two recently acquired specimens show the range extending somewhat farther south. EHT-HMS No. 3490 is from the city of Songkhla, collected by Dr. Robert Elbel; and EHT-HMS 3908, Na Pradoo, Pattani, collected by Nai Prayoon Kananuracks.

In these the median blackish figure on the neck reaches to the frontal but does not connect with the two blackish diagonal bars crossing jaw-angles and bending across the throat forming a continuous unbroken bar on throat in one, while in the other the mark is interrupted mesially. The Songkhla specimen has only about ten scattered quadrangular spots; the Na Pradoo specimen is almost immaculate for nearly eight centimeters and two centimeters from tip of tail, while the remainder is heavily spotted with black bars or quadrangular black spots alternating. The venter of the Songkhla specimen was salmon pink. That of the Na Pradoo specimen, now cream, may have been so colored in life.

The ventral-subcaudal counts are respectively, 146, 42, and 155, 42.

Na Pradoo is 7° North latitude.

Oligodon joynsoni (Smith)

Simotes longicauda joynsoni M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 4, Dec. 1917, pp. 276-277 (type-locality valley of the Maa Yome, Muang Ngow, Northern Thailand).

Holarchus longicauda: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4, July 25, 1922, p. 208 (*part.*).

Oligodon joynsoni: M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, p. 218, fig. 72 (dorsal pattern).

Diagnosis: A medium-sized species (760 mm. in length); bodily configuration similar to *cyclurus;* eight supralabials; a subocular and a preocular present; scales smooth in 17 rows at middle of body, 15 shortly behind middle; ventrals feebly angulate; dark purplish brown with strong black reticulations forming more or less distinct but broken crossbars, each alternate one with a transversely placed black spot; venter red in life, heavily marked with rectangular black spots; a narrow chevron terminating on head; a crescent spot across eyes and snout; two temporal bars. Ventrals, 187-197; subcaudals, 40-50.

Description of species (data from type description): Rostral bent over tip of snout, portion visible above as long as its distance from frontal; suture between internasals shorter than that between prefrontals; frontal longer than its distance from end of snout, as long as parietals; loreal slightly longer than deep; one preocular (usually one presubocular) and two postoculars; temporals, 1 + 2 (or 1 + 1 + 2, anterior small); eight supralabials, fourth and fifth bordering orbit; five infralabials touching first chinshields which are twice as large as posterior pair; nasals divided.

Scale-formula: 17, 17, 15, 15, the reduction taking place just posterior to mid-body; ventrals, 190; anal, single; subcaudals, 47; maxillary teeth, 12, steadily increasing in size posteriorly; palatine teeth, 7, pterygoid, 14.

Color: Purplish brown above with ill-defined broken bands across back, every alternate one enlarged into a dorsal blotch, about 50 altogether on body and tail; below yellowish white with rather large black quadrangular spots not reaching outer lateral part of ventrals; a large dark-brown crescentic band in front, passing across prefrontals and through eyes; an oblique temporal streak present, and a narrow chevron on nape terminating on frontal.

Measurements in mm.: Total length, 760; tail, 105.

Variation: A second specimen differs in having the frontal shorter than the parietals, a subocular present, and only seven supralabials on left side (due to fusion of the second and third). The ventrals are 187, the subcaudals 50. It is light brown above, the dorsal blotches being scarcely enlarged. Below it is uniform yellowish white. Other specimens show that the subocular below the preocular may be absent and there may be one or two anterior temporals. Ventrals vary between 187 and 195, the subcaudals between 43 and 50. The venter is always reddish in life.

Remarks: Smith himself seems to have had some doubts as to the validity of this species. In 1922 he referred the form to *Oligodon longicauda*. He states: "the difference in colouration between them was far less than I gathered from the description, so much so that mine can no longer be recognized as a form apart." However in 1943 he recognizes *joynsoni*, not as a subspecies of *longicauda*, but as a distinct species. Not having examined material of this species I accept Smith's 1943 decision as to its status.

Distribution: Known only in the type-locality and from Me Wang, Northern Thailand.

Genus *Liopeltis* Fitzinger

Liopeltis Fitzinger, Systema reptilia, 1843, p. 26 (type of genus, *Herpetodryas tricolor*).

Gongylosoma Fitzinger, *ibid.*, p. 25 (type of genus, *Coronella baliodeira.*

Ablabes Duméril, Mem. Acad. Sci. Paris, vol. 23, p. 454 (type of genus, *Coronella balioderia*).

Diagnosis: Small snakes, scales in 13-17 rows around body (13 in Thai forms), not reducing posteriorly; apical pits lacking; one preocular, one or two postoculars. Maxillary teeth, 24-28, about equal in size in Thai species. Head not or scarcely distinct from neck in Thai species.

Two species are recognized in Thailand: *scriptus* and *baliodeirus.* The latter is represented by a recently described subspecies *b. cochranae.* The two forms may be separated by the following key:

1. Ventrals, 115-137; subcaudals, 58-75; eight supralabials; several dark bands around anterior part of body; two preoculars; two postoculars, *baliodeirus cochranae*
2. Ventrals, 117-145; subcaudals, 89-103; supralabials eight; a narrow interrupted band across occiput, bordered with black, followed by a broad somewhat darker saddle-shaped blotch..... *scriptus*

Liopeltis baliodeirus Boie *in* Boie

Coronella baliodeira Boie *in* Boie, Isis, 1827, 539 (type-locality, Java): Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 64, pl. 2, figs. 9, 10 (including a "*var.*" in Sumatra); Cantor, Journ. Asiat. Soc. Bengal, vol. 16, pt. 2, 1847, p. 913.

Ablabes baliodeirus: Duméril, Bibron and Duméril, Erpétologie générale . . . 1854, p. 313; Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858, p. 29; The reptiles of British India, 1864, p. 224; Flower, Proc. Zool. Soc. London, 1899, p. 673; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 152; Catalogue of the snakes . . . vol. 2, 1894, pp. 283-284.

Diadophis baliodeirus: Jan, Arch. Zool. Anat. Fis., vol. 2, 1863, 263; Jan and Sordelli, Iconographie générale, livr. 15, pl. 5, fig. 4.

Gongylosoma baliodeirum: Sworder, Singapore Nat., no. 2, 1922, p. 65; *ibid.*, no. 3, 1921, p. 22 (Singapore). M. Smith, Bull. Raffles Mus., no. 3, 1930 pp. 56-57.

It is obvious from the variation reported, that several subspecies of this snake exist. Schlegel recognized a "*var.*" in Sumatra. (Schlegel, Atlas, on—"Tableau servant a illustrer la répartition des serpent a la surface du globe"). J. A. Fisher, described *Ablabes baliodirus* var. *cinctus* (Abh. natur. Ver Hamburg, vol. 9, 1886 (1885), p. 8, pl. 1, fig. 2, from Nias).

I have not seen specimens of this species from Malaya. It is known in Penang, Province Wellesley and on Bujong Malacca, Perak (*fide* Boulenger, 1912).

Whether any of these specimens are the same as the form described here, remains to be ascertained.

Liopeltis balioderius cochranae Taylor

(Fig. 42)

Liopeltis baliodeirus cochranae Taylor, Univ. Kans. Sci. Bull., vol. 43, 1962, pp. 261-263, fig. 18 (type-locality, Khao Soi Dao, Thailand).

Diagnosis: Thirteen scalerows around body; nostril between two nasals fused above nostril; head scarcely distinct from neck; two preoculars, two postoculars; eight supralabials, the fourth and fifth border eye; 24-25 maxillary teeth; neck with eight or nine black bands (reaching to ventrals) all except first, third, and fourth interrupted on median dorsal line.

Description of type: Head a little wider than neck; rostral not twice as wide as high, narrowly visible above on snout; internasals wider than long, much smaller and narrower than prefrontals; latter much broader than long, laterally touching loreal, posterior nasal, and upper preocular; frontal shield-shaped, longer than its distance from tip of snout, shorter than parietals; nostril between two nasals that are fused above nostril, the posterior nasal largest, distinctly higher than anterior nasal; a small loreal; two preoculars, upper not reaching upper surface of head; supraoculars large, not as wide as frontal; two postoculars; a single large anterior temporal followed by two superimposed temporals much shorter than anterior; eight supralabials in the following order of size: 3, 2, 1, 6, 4, 5, 8, 7; the fourth and fifth enter orbit; mental triangular, first labials in contact behind it; seven infralabials, first three touch first chinshields which are much shorter than second pair.

Scalerow-formula: 17 (occiput), 13, 13, 13: scales smooth, without apical pits. Ventrals, 118; subcaudals, 72; anal, divided.

Color: Head nearly uniform light brown; on side of head very slight dark marks evident along sutures of some labials and a fine dark rim on edges of scales marking outline of orbit; on occiput the brown tends to become blackish in front of first cream bar which is angulate anteriorly and almost broken on side; this followed by a series of eight or nine blackish bars (some of which are broken by a middorsal light line), and separated by dull cream or fawn-colored bars; dark and light bars becoming less distinct posteriorly where they fade into the uniform, finely reticulated pattern of violet brown, each scale with a diamond-shaped light, gray-lavender center,—a pattern that continues to tip of tail. Outer edge of ventrals

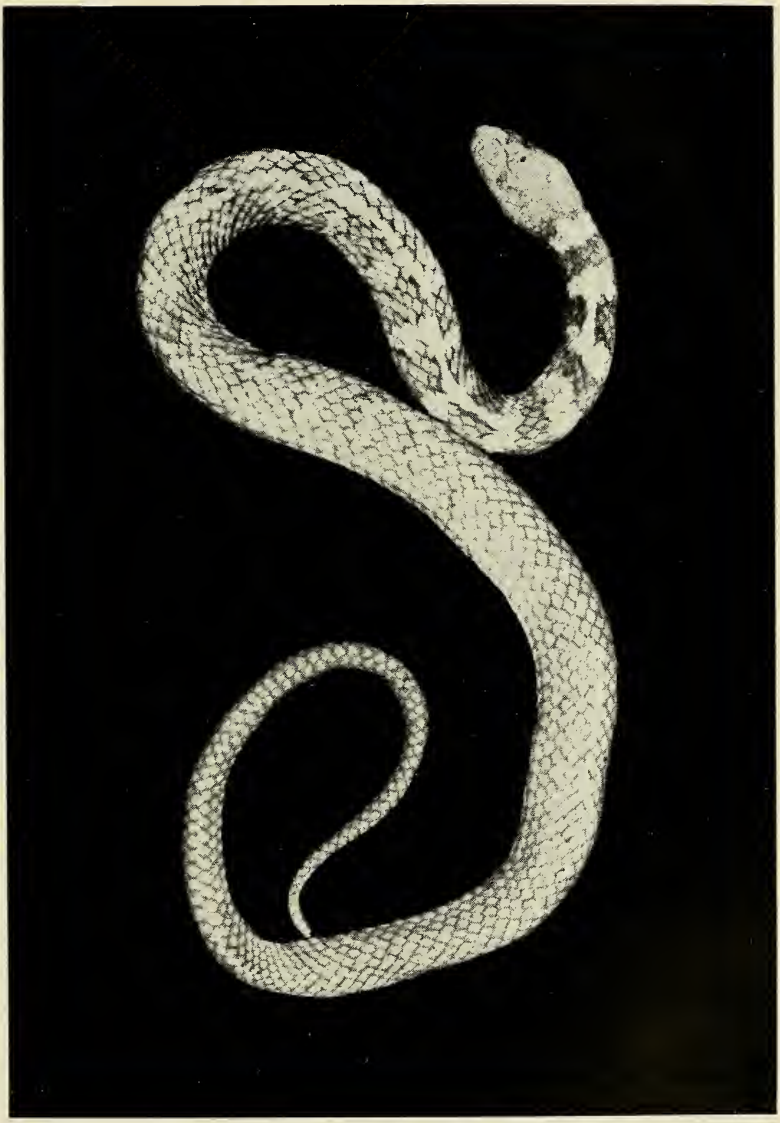

FIG. 42. *Liopeltis baliodeirus cochranae* Taylor. Type, USNM No. 94826 (6343), Khao Soi Dao, Thailand. Actual total length, 374; tail, 118. (From Taylor, 1962.)

and subcaudals with a violet-brown line separating the uniform whitish color of underside of head, body, and tail from the dorsal coloration.

Measurements in mm.: Snout to vent, 256; tail 118; total length, 374; width of head, 9.1; length of head, 14.

Remarks: Another species of the genus, *Liopeltis scriptus* (Theobald), also occurs in peninsular Thailand and specimens have been taken in the Nakhon Si Thammarat Mountains (Khao Luang and Ronpibon), and on Pulau Panjang (Island) of Phuket.

The differences are considerable in these two forms, both having 13 scalerows about the body. In *b. cochranae* ventrals are fewer, 118 compared with 122-145; the subcaudals fewer, 72, compared with 87-103. There are two instead of three supralabial scales bordering orbit; the nasals are partly fused (two separate), and the anterior temporal is wider and somewhat shorter than in *L. scriptus*. The subspecies in known only from the type-locality.

Liopeltis scriptus (Theobald)

(Fig. 43)

Ablabes scriptus Theobald, Journ. Linnean Soc., vol. 10, no. 41, Zoology, 1868, p. 42 (type-locality, Martaban, Burma); Catalogue of the reptiles in the museum of the Asiatic Society of Bengal (Extra no. of Jour. Asiat. Soc. Bengal, 1868, p. 49); Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 305-306; Catalogue of the snakes in the British Museum, 2nd ed. vol. 2, 1894, p. 284.

Liopeltis scriptus: Wall, Journ. Bombay, Nat. Hist. Soc., vol. 29, 1924, p. 864.

Gongylosoma scriptum: Cochran, Proc. U. S. Nat. Mus., vol. 77, pt. 2, 1930, p. 30; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 56-57 ("Petchaburi District" Thailand; Telok Poh, Phuket; Khao Luang, Nakhon Si Thammarat); The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 186-187, fig. 57.

Diagnosis: Small snake, reaching about half meter in length; scales in 13 smooth rows throughout body; eight supralabials, third and fourth entering eye; anterior temporal longer than secondary temporals; a narrow black-edged broken cream band across occiput, preceding a dark neck band; supralabials cream with some black along certain sutures.

Description of species (from No. 35587 Ronpibon, Nakhon Si Thammarat): Rostral not twice as wide as high, visible above; internasals moderately large touching nasals laterally, smaller than prefrontals; latter nearly twice as wide as long, touching posterior nasal, loreal, and preocular laterally; frontal longer than its distance from tip of snout, shorter than parietals; nasal divided, anterior part angular and a little the larger, posterior part rounded behind;

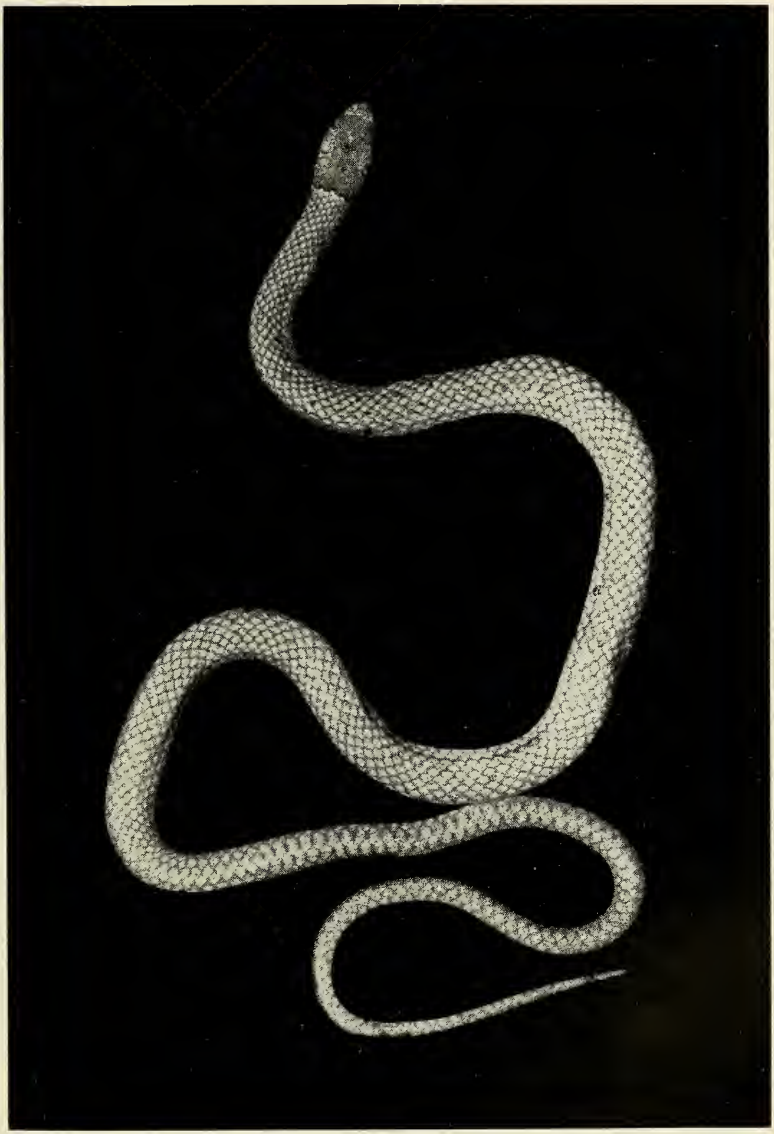

FIG. 43. *Liopeltis scriptus* (Theobald). No. 35587, Ronpibon, Nakhon Si Thammarat, Thailand. Actual total length, 355 mm.; tail, 152 mm.

loreal small, a little higher than long; single preocular high and narrow, but not reaching top of head; supraoculars little more than half width of frontal; two postoculars both touching anterior temporal; temporals, 1 + 2, anterior longer than posterior; eight supralabials, third, fourth, and fifth border orbit; seventh distinctly the largest; diameter of eye equal to its distance from rostral; eight infralabials, last very small, first four border first chinshields which are shorter than second pair.

Scales in 13 rows around body; ventrals, 122; anals, 2; subcaudals, 103 (104).

Color: Above generally grayish, scale edges darker brown; two outer scalerows with edges of scales less distinctly marked except on scales bordering third scalerow, where edges are a little more heavily marked, leaving a slightly darker line the length of body. Head gray to brownish gray above, anterior part dimly flecked with darker; side of snout light fawn with dark marks on rostral, nasal sutures, and on first and second supralabials; a narrow black ring around eye, widening considerably on labials below eye; a cream line from fifth and sixth labials pushes up back of eye partially bordered behind by black; a black-edged cream line from eighth supralabial reaches to or nearly to parietal; a dark band four or five scales wide on neck, bordered narrowly by cream posteriorly; venter and subcaudal region cream.

Measurements in mm.: Snout to vent, 203; tail, 152; total length, 355; width of head, 6.3; length of head, 12.

Variation: USNM No. 76103 is also from Nakhon Si Thammarat. It has 133 ventrals and 98 subcaudals. The head and body measure 240 mm., the tail 160 mm.; it differs in having two preoculars and the light transverse mark behind the dim nuchal band is scarcely discernible; a few tiny punctate black flecks present for about two inches behind head.

The ventrals are known to vary between 122 and 145, the subcaudals, 87 to 103.

Distribution: In Thailand the species is known from Sai Yoke, Kanchanaburi province; Khao Luang and Ronpibon, Nakhon Si Thammarat; Pulao Panjang (Island), Phuket.

It has not been reported outside Thailand except in Burma (Martaban), the type-locality.

Genus *Dryocalamus* Günther

Dryocalamus Günther, Catalogue of the colubrine snakes in the British Museum, p. 112 (type, *D. tristrigatus*).

Diagnosis: Eye large with a vertical pupil; scales in 13 or 15 subequal rows, normally imbricating, with apical pits present. Hypapophyses lacking on posterior body vertebrae. Maxillary bone curving inward anterior to palatine; teeth on maxillary 8 to 10, increasing in size posteriorly.

The genus ranges from India throughout southeastern Asia, Malaya to the Philippines. One species is known from Thailand.

Dryocalamus davisonii (Blanford)

(Fig. 44)

Ulupe davisonii Blanford, Journ. Asiat. Soc. Bengal, vol. 47, 1878, p. 128 (type-locality, Nawlabu Hill, East of Tavoy, Burma); Proc. Zool. Soc. London, 1881, p. 221.

Hydrophobus davisonii: Boulenger, Fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 299.

Dryocalamus davisonii: Boulenger, Catalogue of the snakes in the British Museum, vol 1, 1893, p. 372; Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 616; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 93; Bourret, Les Serpents de l'Indochine, 1936, p. 168; M. Smith, Fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese Subregion; Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 274-275. Taylor and Elbel, Univ. Kan. Sci. Bull., vol. 38, pt. 2, 1958, p. 1044 (listed as *D. davidsonii* [*sic*]).

Diagnosis: Nostril in a single nasal; no preocular, loreal entering orbit of eye; scales in 13 rows; black above, banded with white or pale green; bands posteriorly shorter than anteriorly; subcaudals paired.

Description of species (from No. 1283, collection of Dr. Boonsong Lekagul): Rostral much wider than high (3.3 × 1.7 mm.), broadly visible above, forming a slight median angle on its upper border; internasals distinctly longer than prefrontals but less wide, narrowed anteriorly, anterior and posterior sides parallel; prefrontals with a slight angle on their posterior border, laterally broadly in contact with loreal, narrowly so with nasal; frontal approximately as long as its distance from end of snout, and equal to its distance from posterior level of parietals; parietals in contact for four-fifths of their length; supraoculars widened posteriorly.

Nostril in an undivided nasal scale somewhat rectangular in shape; preocular absent; loreal broadly entering orbit of eye; eye large, pupil vertically elliptic; two postoculars; anterior temporals, one on right, two on left side; temporal formula, $1 + 2 + 2 + 3$ (right side), $2 + 2 + 1 + \frac{1}{2}$ (left side); seven upper labials, third and fourth enter orbit; eight lower labials, anterior four touch first

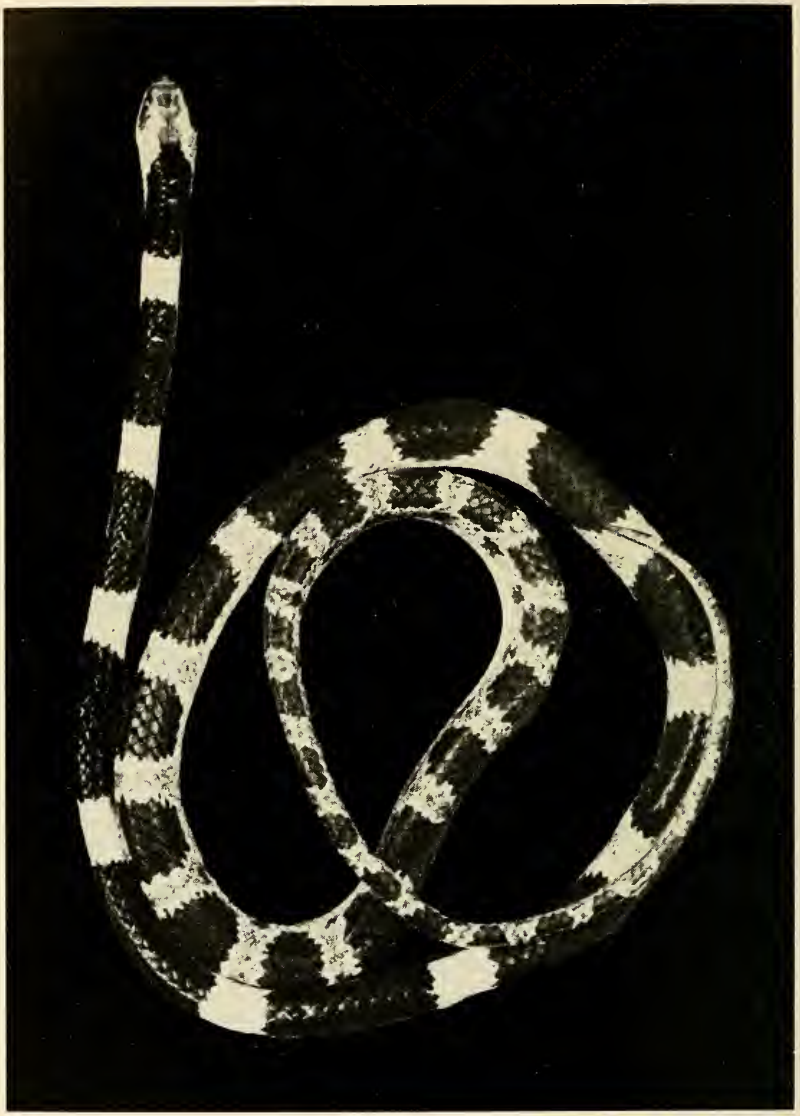

FIG. 44. *Dryocalamus davisonii* (Blanford). No. 900 ♂, Chalermlaub, Sriracha, Chon Buri province, southeastern Thailand. Actual total length, 444 mm.; tail, 74 mm.

chinshields which are more than double size of posterior pairs; four pairs of chinshields.

Scalerow formula: 17 (occiput), 13, 13, 13; scales small with single apical pits; ventral scales, 233; subcaudal scales, 92; anal, single; ventrals keeled, with a slight notch on each side.

Color: Above with 27 black saddle-shaped blotches narrowed laterally, reaching to ventrals (anteriorly) and posteriorly to outer scalerow or to second or third outer row near vent; the length of saddles anteriorly are equal to 13 scale-lengths; farther back to eight scale-lengths growing gradually shorter to five and four preceding level of vent; a second series, at first small, begins on second row at 14th blotch and continues to vent, growing larger and alternating with dorsal blotches. The intervening lighter areas, whitish anteriorly, become cloudy with darker pigment except for a single row of scales bordering dark blotches. The light intervening areas are widened laterally and narrowed dorsally, the edges of both light and dark areas being denticulate; head with a light brown mark covering frontal region to snout with a median posterior mark reaching to first dorsal blotch and to posterior projection passing through eye and onto two temporals; posterior occipital region with a dusting of pigment; chin and venter nearly pure white with a few dark spots on latter fifth; considerable pigment on subcaudals, dense mesially.

Measurements in mm.: See table.

Measurements in mm. and scale data on *Dryocalamus davisonii*

NUMBER	1283	1756 ♀	900 ♂
Snout-vent length	536	557	370
Tail length	152	164	74
Total length	688	721	444
Width of head	9	10.3	7
Length of head	14.6	16	12
Ventrals	233	238	238
Subcaudals	92	95	61+
Preoculars	0	0	0
Postoculars	2	1	1
Supralabials	7	7	7
Chinshield, pairs	4	4	4

Variation: Known variation in ventral count is between 233 and 255, the subcaudals between 90 and 108. The loreal may enter the eye. Seven or eight supralabials are present.

The species reaches a length of 920 mm.; the tail 205 mm.

Distribution: In Thailand specimens have been reported between 18° and 11° north latitude. I have taken the species in Chalermlaub, Sriracha, Chon Buri from under the bark of a stump. M. Smith reports two specimens taken from Sapatoom, Bangkok.

The species ranges from Burma to Indo-China.

Remarks: This is a lowland species and cannot be considered common. The eggs of the species are remarkably elongate. Smith (1943) reports the size of four laid by a captive specimen as measuring 39 mm. × 9 mm.

Genus *Plagiopholis* Boulenger

Plagiopholis Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 301, (type of genus, *blakewayi*).

Trirhinopholis Boulenger, Catalogue of the snakes in the British Museum, vol. 1, 1893, p. 419, (type, *nuchalis*).

Diagnosis: Maxillary teeth 16-20, small subequal; nostril between two nasals; eye with a vertical subelliptical pupil; scales smooth or with keels posteriorly on body and base of tail; scales in 15 rows, more or less obliquely arranged, without apical pits. Body cylindrical, head not distinct from neck; subcaudals all or mostly divided; hypapophyses throughout vertebral column; mental touching first chinshields.

Four species are recognized. These are distributed through Burma, northern Thailand, southern China, and Indo-China.

A single species, *Plagiopholis nuchalis,* has been taken in Thailand, this from the area north of latitude 13°.

Plagiopholis nuchalis (Boulenger)

(Fig. 45)

Trirhinopholis nuchalis Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 419, pl. 38, fig. 1, (type-locality, Toungyi, S. Shan States); *ibid.*, vol. 3, 1896, p. 612; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 323; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 2, Mar., 1915, pp. 155, 213, (specimens from near border of Thailand, Sai Yoke district); Journ. Bombay Nat. Hist. So., vol. 23, 1915; Wall, *ibid.*, vol. 29, 1923, pp. 466, (Sinbur Kaba, Upper Burma), 612; *ibid.*, vol. 30, 1925, p. 811, (13 specimens, Kachin Hills and Kut Kai, North Shan Hills, Burma); *ibid.*, vol. 31, 1926, p. 561; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, June, 1934, pp. 302-304.

Plagiopholis nuchalis: M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 484; The fauna of British India, Ceylon, and Burma including the whole Indo-Chinese subregion, Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 326-327.

Oligodon evansi Wall, Journ. Bombay Nat. Hist. Soc., vol. 22, 1913, p. 514, fig., (type-locality, Toungyi, S. Shan States) and *ibid.*, vol. 27, 1920, p. 175, [= *P. nuchalis*].

Diagnosis: A small snake (470 mm.) resembling somewhat a species of *Oligodon;* ventrals, 122-142, subcaudals, 23-30; six supralabials; loreal present; 15 scalerows, smooth except in anal region; first infralabials separated by first chinshields, which touch mental.

Description of species (from No. 33635, Doi Suthep, Chiang Mai, north Thailand): Rostral broader than high, part visible above

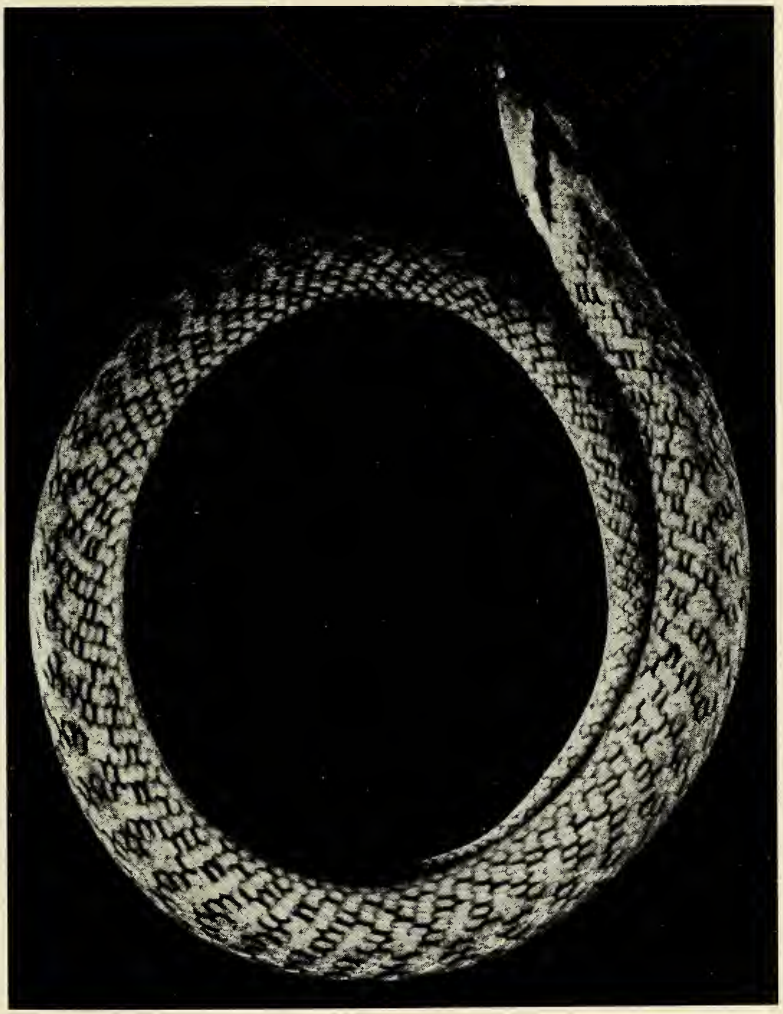

FIG. 45. *Plagiopholis* nuchalis (Boulenger). No. 33635, Doi Suthep, at Forest Station, Chiang Mai, Chiang Mai province. Actual length, 238 mm.; tail, 26 mm.

about equal in width to suture between small internasals, which are less than half area of prefrontals; frontal much longer than its distance to end of snout, slightly less than length of parietals; scales bordering temporals and parietals somewhat larger than body scales; each prefrontal is fused to frontal by a narrow isthmus (presumably abnormally but symmetrically); nostril between two nasals; a quadrangular loreal present, touching one labial; a verti-

cally elongate preocular; a broad supraocular; two postoculars; temporals, 1 + 2; six supralabials, third and fourth enter eye, fifth much the largest, sixth second in size; six infralabials, three touching large anterior chinshields, which are considerably larger than second pair; first infralabials separated behind mental; scales smooth except near tail in 15 rows throughout, those of two outer rows largest; scales arranged somewhat obliquely (but not conspicuously so) and keeled in posterior part of body.

Diameter of eye much larger (nearly double) its distance from mouth; ventral scales, 126; anal, single; subcaudals, incomplete.

Color in life: Somewhat reddish brown with many of the scales edged with black and forming about 56 single or double transverse dark markings across back, which may connect to form a reticulum; ventral scales yellowish, with irregular rows of rather large rectangular black marks on each side of venter and in subcaudal region; head yellowish olive with a strong chevron-shaped black spot pointing forwards and terminating at parietals; chin and throat yellowish as far as fourth ventral; two vertical dark marks below eye.

Table of measurements and data on *Plagiopholis nuchalis*

NUMBER	33635	19890	675 ♀
Total length	238	.....	376
Tail	26	.....	42
Width of head	8	.....	9.5
Length of head	12.1	.....	16
Supralabials	6	6	6
Infralabials	6	6	6
Temporals	1+2	1+2 1+½	1+2
Supralabials in eye	3, 4	3, 4	3, 4
Ventrals	126	129	128
Subcaudals	?	29	28
Maxillary teeth	19	19	20
Scale formula	15–15–15	15–15–15	15–15–15

All from Doi Suthep, Chiang Mai.

Variation: The subcaudals are normally divided but occasionally some may be single. The ventrals vary from 122 to 142; subcaudals, 23 to 30. The reticulation may leave a dorsolateral series of rounded black spots connected with each other by brown crossbars or a series of obliquely placed light brown, black-edged, crossbars. Rarely the spots on venter may be absent.

A second specimen, No. 675 ♀, was taken at an elevation of approximately 1,000 meters on Doi Suthep. The specimen was found crawling in short grass where it moved with considerable rapidity for a snake of its size and structure.

The chevron terminates on the parietals but more or less connects with a blackish line which outlines the frontal and the sutures that touch the frontal. Besides the heavy black bars on venter, a great deal of the remaining surface is heavily peppered with gray pigment.

Distribution: The species seems to be confined to Burma and Thailand. It has been taken at the Thai-Burmese border in the Sai Yoke district, Kanchanaburi province; at Chiang Mai, Doi Ang-Ka, and Doi Suthep, Chiang Mai province; Khun Tan. The specimen here described is from Doi Suthep.

Remarks: In general appearance this snake resembles that of a species of the genus *Oligodon,* having a characteristic chevron on the neck. The separation of the first labials will easily separate *Plagiopholis* from *Oligodon.* There are 17 small maxillary teeth of nearly equal size, the first one or two smallest.

M. Smith has united *Plagiopholis* Boulenger with *Trirhinopholis* an action followed here without certainty that this represents the true relationship.

Genus *Pseudorabdion* Jan

Pseudorabdion Jan, Arch. Zool. Anat. Fis., Genova, vol. 2, 1862, p. 10 (type, *Rabdion torquatum*).

Diagnosis: Small snakes; eye not covered by scutes; internasals and prefrontals present; supraocular present; no anterior temporal; five or six supralabials; scales in 15 longitudinal rows, smooth, without apical pits; anal single, subcaudals double.

The genus is distributed in the Malay Peninsula and in the Indo-Australian Archipelago as far as the Philippines. A single species occurs in Thailand.

Pseudorabdion longiceps (Cantor)

Calamaria longiceps Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1947, p. 910, pl. 40, fig. 1 (type-locality "Pinang" = Penang).

Oxycalamus longiceps: Günther, The reptiles of British India, 1864, p. 199; Stoliczka, Journ. Asiat. Soc. Bengal, vol. 42, 1873, p. 120; Blanford, Proc. Zool. Soc. London, 1881, p. 218 (Singapore).

Pseudorhabdion longiceps: Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 16, 1885, p. 389; Bourret, Les serpents de l'Indo-Chine, 1936, p. 226, fig. 105; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 57 (Bangnara = Narathiwat,

Narathiwat); Leviton and Brown, Proc. California Acad. Sci., ser. 4, vol. 29, no. 14, May 29, 1959, pp. 481-486 (literature list); Tweedie, Snakes of Malaya, 1954, pp. 51-52, fig. 12, a and b; *ibid.*, 2nd Ed., 1957, pp. 33, 133, figs. 13, a and b.

Pseudorhabdium longiceps: Boulenger, Catalogue of the snakes in the British Mus., 2nd Ed., vol. 2, 1894, p. 329; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 154; Flower, Proc. Zool. Soc. London, 1896, p. 886; Robinson and Kloss, Journ. Federated Malay States Mus., vol. 8, 1920, p. 303; Sworder, Singapore Nat., 1923, p. 65; Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 161; Journ. Federated Malay States Mus., vol. 10, 1922, p. 267 (Frazer's Hill, Malaya).

Rhabdion torquatum Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, pp. 119-122, (type-locality, "Macassar"); Peters, Mon. Akad. Wiss. Berlin, 1861, p. 684.

Pseudorhabdion torquatum: Jan and Sordelli, Iconographie générale des ophidiens, 1865, livr. 10, pl. 3, fig. 3.

Diagnosis: A diminutive snake reaching a length of little more than 200 mm. Slate-gray above and below; scales in 15 rows throughout length of body; anal single; mental in contact with the first chinshields; internasals small, one third size of prefrontals which are but little less in size than frontal; parietal touching labials; ventrals, 141; subcaudals, 19.

Description of species (from No. 35560 Bhetong, Yala province): Rostral higher than wide, part visible above forms a very small triangle; internasals less than a third as large as prefrontals, separated from labials; prefrontals very large, touching three first labials, the first very narrowly; frontal only a little larger than prefrontals, longer than its distance from tip of snout, about three times as broad as narrow supraoculars, much shorter than parietals; nostril pierced in anterior end of single nasal; no loreal; one small preocular, one postocular, the latter touching two labials. No anterior temporal, posterior temporal very large; six supralabials, first smallest, fifth largest, third and fourth entering orbit; six infralabials, first pair small, widely separated, first three touching first chinshields which are nearly double size of second pair and in contact with mental; eye diameter greater than distance of eye to mouth.

Scale-formula: 15-15-15, scales without apical pits. Ventrals, 141; subcaudals, 19; anal, single.

Color in life: Slate-gray or bluish gray, scales with slightly lighter edges; ventrals grayish brown, posterior edges slightly lighter; top of head darker than sides; some lighter marking on chin and labials.

Measurements in mm.: Total length, 208 mm.; tail, 15.5; head width, 4.2; head length, 7.3; greatest width of body (female with eggs), 7 mm.

Distribution: The species is known in Thailand only in the two southernmost provinces, Yala and Narathiwat. Outside of Thailand the species occurs in Malaya and has been reported in Sumatra, Borneo, Celebes, and the Philippines. Leviton and Brown (1959) question the Philippine reports.

Remarks: I collected this small specimen about four kilometers from Bhetong, Yala province, on the edge of a rice-paddy ditch, among dead leaves. The specimen is a gravid female containing three eggs. Another specimen was taken by me on Singapore Island.

Genus *Calamaria* Boie

Calamaria Boie, Isis, 1826, p. 981; *ibid.*, 1827, p. 519, 539 (type of genus, *linnaei*); M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 236-237 (fixation of type).

Diagnosis: Small cylindrical snakes, head not or scarcely distinguished from neck. Eye with a round pupil, the nostril pierced in a tiny nasal; loreal absent; internasals and prefrontals fused; supraocular reduced; preocular present or absent; scales smooth, in 13 scalerows; subcaudals paired; no apical pits. Maxillary teeth eight to eleven, all curving, subequal.

Five species of this typically Malayan genus *Calamaria* enter Thailand.

They may be distinguished by the following key:

KEY TO THAI SPECIES OF CALAMARIA

1. First pair of labials not in contact behind mental; chinshields and mental touch; five supralabials, third and fourth enter eye; venter ivory with numerous blackish or slate bars; tip of tail pointed..... *vermiformis*
   First pair of labials in contact behind the mental; tip of tail variable..... 2
2. Five supralabials; frontal four times as wide as supraocular; chin and venter ivory-white (head color variable); third and fourth supralabials border eye; tail pointed..... *leucocephala*
   Four supralabials;..... 3
3. No nuchal dark band bordered by yellow; nearly uniform blackish or brownish violet above; second scalerow with light dots on each scale; venter ivory (pinkish in life?); tail ending in a rounded scale..... *uniformis*
   A nuchal dark band bordered with yellow..... 4
4. Five rows of black dots on dorsum; frontal twice as wide as supraocular; tail pointed, lacking paired white spots; venter white except that lateral pigment extends onto ends of ventrals..... *p. pavimentata*
   Nuchal black band bordered fore and aft with yellow. Two (or three) pairs of yellow spots on tail; ventrals strongly edged with brown or gray, in older specimens venter nearly uniform gray..... *siamensis*

Calamaria vermiformis Duméril, Bibron, and Duméril

Calamaria vermiformis Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, pp. 85-87 (type-locality, Java); Jan and Sordelli, Iconographie générale des ophidiens, livr. 10, pl. 2, fig. 3; Boulenger, Cata-

logue of the snakes in the British Museum, 2nd Ed., vol. 2, 1894, p. 333-335 (*part.*) *ibid.*, vol. 3, 1896, p. 646; A vertebrate fauna of the Malay Peninsula; Reptilia and Batrachia, 1912, pp. 155-156 (Perak, 4,000 ft.); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 162 ("Bangnara, Patani" = Narathiwat, Narathiwat); Bull. Raffles Mus., no. 3, 1930, p. 57 (not recorded north of Patani = Narathiwat); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 153-154 (*part.*) (Sumatra, Java, Borneo, Natuna Ids., Ternate, Malay Peninsula); Tweedie, The snakes of Malaya, 1954, p. 49, fig. 11.

Diagnosis: Small snake, usually under 400 mm. in length; five supralabials, third and fourth border eye; first chinshields in contact with mental, separating first labials; frontal not twice as broad as supraocular; 13 scalerows. Tail terminating in a point.

Dark brown or black above; head often partially or entirely yellowish or whitish; outer scalerows whitish; yellowish beneath with large black transverse spots.

Description of species (from B. M. No. 1900.6.14.21 Larut Hills, Perak, 4000 feet): Rostral about one-and-one-half times wider than high, well visible above; internasals and prefrontals fused, the combined scales narrowed anteriorly, laterally touching nasals, two labials and a preocular; frontal shield-shaped about twice width of supraocular, a little shorter than its distance from tip of snout, shorter than parietals; nostril in a single small nasal scale that is about one third of area of first labial; preocular not reaching upper surface of head; supraocular moderately large; a single postocular touching parietal and fifth supralabial; five supralabials, fifth much the largest, third and fourth bordering eye; no anterior temporal, but one large secondary; mental as wide as lower edge of rostral, in contact with anterior chinshields, which are in contact with three labials, and distinctly larger than second chinshields; the two pairs of chinshields nearly enclosing a large azygos scale that separates second pair; mental groove poorly developed.

Scale-formula: 13, 13, 15. Ventrals, 164; anal, single; subcaudals (divided except last), 27; tail ending in a definite spine, directed downwards.

Color: Above brownish lavender on the nine dorsal scalerows; two outer scalerows with an ivory stripe covering greater part of both rows (on outer row only on tail); infralabials, chin, and throat (for one-half inch), ivory; venter transversely barred with dark slate and ivory; bands irregular in width, and ivory bands between them also irregular and flecked with slate; lower half of supralabials ivory, with a more conspicuous ivory-white area covering large fifth supralabial, which color is not continuous with the ventrolateral ivory stripe.

Measurements in mm.: Snout to vent, 345; tail, 43; total length, 388; width of head, 9.1; length of head, 13.5.

Variation: It is a generally accepted idea that this species has what are called numerous color-forms, some very strikingly different from the one described here. The specimen described is from a Malayan locality relatively near the border of Thailand.

Distribution: A single specimen, taken in Thailand although not so stated is probably from "Bangnara" [= Narathiwat, Narathiwat] which is one of the border provinces (formerly a part of the province of Pattani). The specimens reported by Malcolm Smith in Thailand and Malaya up to 4,000 ft. all belong to this color form. Tweedie, *loc. cit.*, however reports a form different from this as follows: "The mountain form, which occurs above 3,000 feet, is dark brown above and each scale is bordered above and below with white so that narrow white lines run along the body between the scalerows. The belly is sharply and regularly barred black and yellowish-white." Tweedie gives the ventral range as 147-210; subcaudals 15-26.

Addenda: A specimen of this species acquired in 1961 at Maxwells Hill, Malaya, EHT-HMS No. 3179 ♂, has the following characteristics: The anterior chinshields are nearly double the size of the second pair; this second pair is widely separated by a single scale so that the mental groove is short and is very poorly indicated (as if approaching a condition in which the groove was absent; three postparietal scales (one abnormally large) between the upper secondary temporals. Ventrals, 168; subcaudals, 26; scale-formula: 13-13-13. The tail is equally as large in diameter as the body preceding vent. On one side of the neck five adjoining scales on rows three and four are fused to form as many large scales (normal on the left side). Total length, 383 mm.; tail, 35mm. The two outer scalerows are cream to ivory. It would be well to reexamine the presumed color varieties to ascertain whether or not they should be regarded as subspecies.

Calamaria leucocephala Duméril, Bibron, and Duméril

Calamaria leucocephala Duméril, Bibron, and Duméril, Erpétologie générale 1854, pp. 83-85 (type-locality, unknown); Günther, The reptiles of British India, 1864, p. 198 ("probably from British India"); Boulenger, Catalogue of the snakes in the British Museum (Natural History) 2nd Ed., vol. 2, 1894, p. 344; Flower, Proc. Zool. Soc. London, 1899, p. 674; Boulenger, A vertebrate fauna of the Malay peninsula . . . Reptilia and Batrachia, 1912, p. 157; M. Smith, Bull. Raffles Museum, no. 3, Apr. 1930, pp. 58-59. Bourret, Les serpents de l'Indochine, vol. 2, 1936, pp. 268-269; Tweedie, The snakes of Malaya, 1953, 1954, p. 50 ("pink headed reed snake"); ? Marx and Inger, Fieldiana; Zoology, vol. 37, June 19, 1955, p. 193 (Singapore; may be a distinct local race).

Calamaria lumbricoidea var. Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 908 (? Malaya).

Calamaria nigro-alba Günther, The reptiles of British India, 1864, p. 198, pl. 18, fig. c (type-locality, Penang).

? *Calamaria agamensis* Bleeker, Nat. Tijdschrift. Nederland-Indië, vol. 21, 1860, p. 292 (*fide* M. Smith) (type-locality, Sumatra).

Diagnosis: A large *Calamaria* reaching a length of 450 mm. The tail 48 mm. Rostral much broader than high; frontal about four times as wide as supraocular; a pre- and postocular; five supralabials, first pair of infralabials in contact behind mental. Above blue-black, highly iridescent; chin, venter, and all or much of outer scalerow ivory white; subcaudals dimly barred with violet; a dim median subcaudal line; tail pointed posteriorly.

Description of species (from No. 3178, collected at Na Pradoo, Pattani, southern Thailand): Rostral distinctly wider than high, part visible above less than half length of prefrontal suture; no internasals; prefrontals very large, a little longer than broad, broadly in contact with second labials, barely touching first labials; frontal distinctly broader than long, its width about four times as great as width of supraocular, its length equal to its distance from tip of snout, and slightly less than its distance from posterior part of parietal; parietals large, longer than wide, their length about equal to their distance from tip of snout; nostril lunate, pierced in a small single nasal that is equally as long as first labial; a preocular; supraocular nearly as wide as long; postocular touching two labials and parietal; no anterior temporal; secondary temporal elongate, bordering parietal laterally; three scales behind parietals intervening between two secondary upper temporals; a smaller median, and a pair of wider postparietals; five supralabials, second touches preocular, third and fourth border eye, fifth largest, broadly in contact with parietal. Five infralabials; first pair broadly in contact behind mental, first three scales border first pair of chinshields; latter a little larger than second pair but scarcely as broad, second pair in contact with each other for less than one third of their length.

Scales very smooth; scale-formula: 15 (occiput), 13, 13, 13. Ventrals, 149; subcaudals, 35, divided, except last which is conical; ventrals separated from chinshields by a row of three small scales.

Color: Above, from snout to tip of tail, dark bluish-black, strongly iridescent. Anteriorly second scalerow ivory-white or partially so for about 60 mm.; outer row completely ivory-white anteriorly but

dorsal color encroaches so that posteriorly only lower edge of row is white; fifth labial largely ivory-white, as are lower edges of other supralabials; entire chin, throat, and venter ivory-white; subcaudals with dim lavender transverse bars on each scale, and a median longitudinal lavender line of same color.

Measurements in mm.: Total length, 362; tail, 54; width of head, 7.9; length of head, 9.8; width of body, 8.

Variation: Considerable variation has been reported in the color of the head. Sometimes it is pure white as suggested by the name, but often this is not so. Tweedie mentions a "pink head" in some of his specimens. Malcolm Smith (*loc. cit.*) has shown that this variation occurs with specimens having a different marking. The preocular may be absent or present in the same series. Despite this fact, subspecific forms may exist in its relatively wide range from Thailand to Java, Sumatra and Borneo. The variation in number of ventrals for males is from 134 to 149; subcaudals, from 24 to 37. For females, 152 and 21. (Data taken by Malcolm Smith on six specimens from Sumatra.)

Distribution: In Thailand, the species is known only from Na Pradoo, Pattani, southern Thailand where a specimen was collected by Nai Pryoon Kananuracks, which he has made available to me for study.

Marx and Inger (*loc. cit.*) refer to this form three specimens probably from Singapore Island. They report four specimens with the preocular entering the orbits which is not true of the type or specimens I have examined in the Kuala Lumpur Medical Institute or in two other specimens, one from Fraser's Hill and the described form. It is not certain what form they had before them since they state, "These specimens agree with all published descriptions of this form."

I have not had any of the white-headed forms for examination.

A Fraser's Hill specimen (EHT-HMS No. 3147 ♂) has 134 ventrals and 31 subcaudals. The color is similar to the described specimen, but each scale appears to have a wide transparent border on the sides and tip. I have referred it to this species.

Other variant characters are: the shape of the nostril is different, the nasal partially or completely divided, the second pair of chinshields narrowly in contact anteriorly, and there is a narrow contact between the first infralabials behind the mental.

Calamaria uniformis M. Smith

(Fig. 46)

Calamaria pavimentata uniformis M. Smith, Proc. Zool. Soc. London, 1921, p. 426 (type-locality, Langbian Peaks, S. Annam, 6000 ft.); The fauna of British India . . . Reptilia and Amphibia; vol. 3, Serpentes, 1943, pp. 238-239.

Diagnosis: A large calamarian (455 mm.), nearly uniformly blackish to brownish violet; dorsal scales somewhat darker on edges; second scalerow with small yellowish or light violet dots on each scale; a cream-white line on lower three fourths of first scalerow; subcaudal area immaculate; scales in 13 rows; five infralabials, the first two in contact behind mental; tail ending in a blunt rounded scale; no nuchal collar or nuchal black spot; no white spots on tail; frontal twice as wide as subrectangular supraoculars; ventrals, 192 ♀, 163 ♂; subcaudals, 18 ♀, 22 ♂.

Description of species (from No. 36529, northern Chiang Mai (province), Gordon Young collector, 1960): A large calamarian; rostral as wide as high, broadly visible above; no internasals; prefrontals almost as large in area as frontal, laterally in contact with two supralabials, a preocular and a nasal; frontal longer than wide, twice as wide as supraocular; its length greater than its distance to end of snout, equally as long as its distance to end of parietal; nostril pierced in a very small triangular nasal scale surrounded by three scales; one small preocular touching prefrontal, supraocular, and second supralabial; a small postocular touching parietal and two supralabials; no anterior temporal; a large elongate secondary temporal bordering parietal; no loreal; four supralabials, second and third bordering eye, fourth largest; five infralabials, first pair in contact behind mental, three anterior ones border first chinshields; second chinshields but little smaller than first pair, in contact for about three fourths of their length; vertical diameter of eye less than its distance from oral margin.

Scale-formula: 15 (about occiput), 13, 13, 13; scales smooth, lacking apical pits. Ventrals, 192; anal, single; subcaudals, 18, divided (except last).

Color: Above iridescent blackish or brownish violet on head, body, and tail, the periphery of scales somewhat darker; body somewhat lighter on sides; lower three fourths of first (outer) scalerow, cream or ivory; second row with lighter median spots, yellowish on anterior sixth, becoming very light violet on remainder of body and less distinct; lower part of supralabials cream-white; chin and

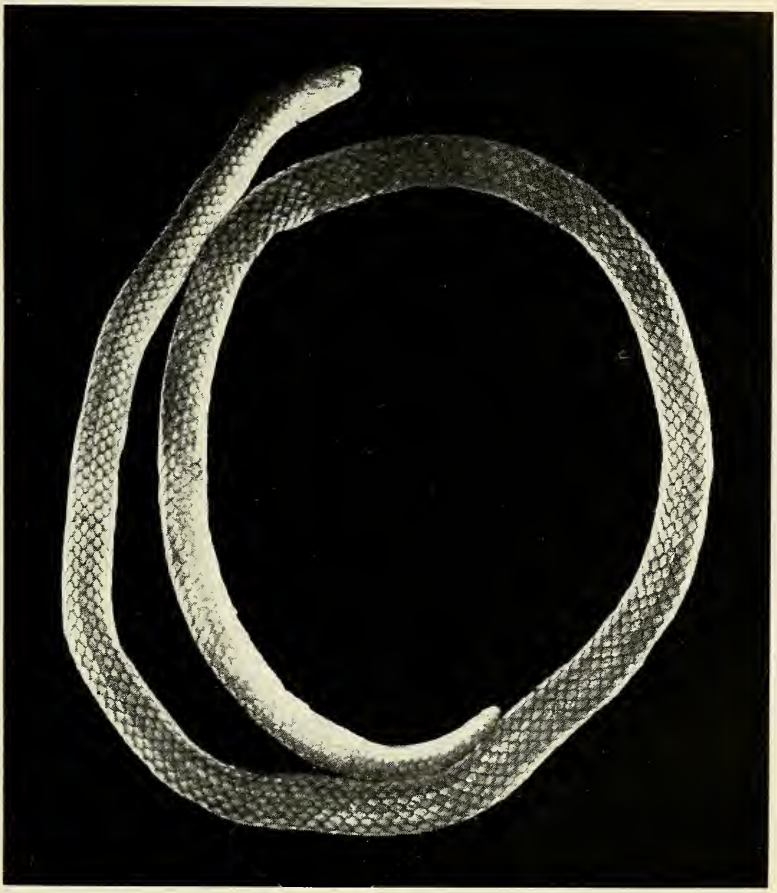

FIG. 46. *Calamaria uniformis* M. Smith. No. 36529, northern Chiang Mai province, northern Thailand. Actual total length, 445 mm.; tail, 24 mm.

infralabials with some dim darker clouding; throat and venter ivory to yellowish cream (pinkish in life?); subcaudal region similar to venter, save that scales of lower caudal scalerow have whitish spots surrounded by darker pigment.

Measurements in mm.: Total length, 455; tail, 24; width of head, 6; length of head, 11; width of body, 9.

Remarks: The single specimen was collected by Gordon Young in the northern Thai province of Chiang Mai, on Doi Suthep a mountain arising near the city. I have examined a specimen (No. 62) presumably of this form, from Cambodia in the Vienna Natural

History Museum. The squamation of the head is practically identical. There are however, only 163 ventrals and 22 subcaudals in this male specimen. The larger number of ventral scales in the described female specimen (192, 29 more than in this specimen) may be due to sex. They are practically identical in color and markings save that the described specimen is of a darker brown and the head is a trifle narrower proportionally.

In the Cambodian specimen there is a faint trace of a darker median line and the outer scalerow has the scale sutures with the ventrals pigmented which is not true of the Thai specimen. In neither specimen is there a trace of median ventral spots, and the subcaudal spots are poorly distinguished.

Distribution: The species is presumably confined to Thailand, Viet Nam and Cambodia. Only known from Chiang Mai province in Thailand.

Calamaria pavimentatus Duméril, Bibron, and Duméril

Although several subspecies have been recognized in this species, only a single one has been found in Thailand. I regard it as the typical one. The type-locality, however, is Java.

Calamaria pavimentata pavimentata Duméril, Bibron and Duméril *

Calamaria pavimentata Duméril, Bibron and Duméril, Erpétologie générale . . . vol. 7, pt. 1, pp. 71-73 (type-locality, Java); Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 282 (*part.*); Catalogue of the snakes in the British Museum, 2nd Ed. vol. 2, 1894, p. 348 (*part.*); Werner, Verh. Ges. Wien, vol. 46, 1896, p. 18; Flower, Proc. Zool. Soc. London, 1896, p. 886; *ibid.*, 1899, p. 675; Laidlaw, Proc. Zool. Soc. London 1901, p. 577; Wall, Proc. Zool. Soc. London, pp. 93, 101; Mocquard, Rev. Coloniale, 1907, p. 45; Boulenger, The vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 157; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1914, p. 213, Proc. Zool. Soc., London, 1921, p. 426; Journ. Federated Malay States Mus., vol 10, 1922, p. 267; Robinson and Kloss, Journ. Federated Malay States Museum, vol. 8, 1923, p. 364; Werner, Zool. Jahrb. vol. 57, 1928, p. 174; Brongersma, Treubia, 1929, p. 67; Smith, Bull, Raffles Mus, no. 3, Apr. 1930, p. 59.

Calamaria pavimentata pavimentata (*part.*) Bourret, Les serpents de l'Indochine, vol. 2, 1936, pp. 270-271, fig. 107. (The drawing shows the mental touching the chinshields. Two subspecies are named.)

Diagnosis: A black collar preceded and followed by yellow; five deep-black rows of dots on dorsum; first pair of infralabials in contact behind the mental; venter yellow; a median line under tail; four supralabials.

* It is entirely possible that certain of these references actually refer to other species or subspecies.

Description of species (from No. 3165, (102) Na Pradoo, Pattani, southern Thailand): Rostral about as broad as high, well visible above; no internasals; prefrontals large, touching two labials laterally, and notched anteriorly by a minute nasal; frontal longer than wide, its sutures with supraoculars parallel, its length greater than its distance to end of snout, and greater than length of the common parietal suture; length of parietal about equal to its distance from tip of snout; nostril pierced in a minute nasal; a small preocular; supraocular less than half width of frontal; a postocular present; an upper secondary temporal borders parietal; no anterior temporal; four supralabials, second and third entering orbit, fourth very large, bordering parietal; mental broader than long; first infralabials in contact behind mental; five infralabials, first three in contact with first pair of chinshields; second pair of chinshields a little smaller than first pair, and in contact only anteriorly. Tail pointed.

Scale formula: 17 (occiput), 13, 13, 13. Scales smooth; ventrals, 153 ♂ ; anal entire; subcaudals 15.

Color: Above rather reddish brown on body with a median and two lateral series of tiny black spots, one spot to each scale in third, fifth, and median scalerows; first, second, fourth and sixth rows with light spots, whitish on two anterior rows, but cream or very light brown on dorsum; spots larger and more regular anteriorly; top of head dark; a black band or bar on neck followed by a yellow ring; chin and throat white, the light color reaching up almost to parietal and covering lower parts of three posterior labials; venter ivory-white except that lateral color extends onto ends of ventrals and subcaudals, lightly so anteriorly, strongly so posteriorly. An indistinct median line extends for some distance under tail.

Measurements in mm.: Total length, 161.5; tail, 10.5; head, width, 3.8; length of head, 5.4; width of body, 4.

Remarks: There is no absolute certainty that the form described here is subspecifically identical with the *Calamaria pavimentata* of Duméril, Bibron, and Duméril from Java. I do not regard it as being subspecifically related to *siamensis*. The strong differences in color, in pattern, in the number of ventrals, in body proportion all suggest strongly a specific relationship.

In *siamensis* the width of the body in total length is about 56-58 times; in *pavimentata pavimentata* here described the width in body length is about 40 times.

A recently acquired young specimen of *Calamaria pavimentatus* measures 336 mm.; tail, 25. It agrees with the described form in essential details. The ventrals are 164, subcaudals, 21. The coloration is brownish with a dim median row of darker flecks, broken at irregular intervals, evident throughout the body but stronger anteriorly. The second scalerow has a series of ivory spots surrounded by body color. The first scalerow is ivory except on upper edges of scales; some brownish flecks on last three infralabials, and a few subcaudal flecks near end of tail.

Calamaria siamensis Günther

(Fig. 47)

Calamaria siamensis Günther, The reptiles of British India, 1864, p. 196 (type-locality, South Laos); Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 60, 66; Theobald, Catalogue of the reptiles of British India, 1876, p. 140; Boettger, Ber. Offenb. Ver. Nat., 1885, p. 121.

Calamaria pavimentatus (*part.*): Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 282; Catalogue of the snakes in the British Museum (Natural History), vol. 2, 1894, p. 348-349.

Calamaria pavimentata: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, p. 213.

Diagnosis: Small, slender snakes usually under 350 mm. in length; 13 scalerows; internasals fused with prefrontals; nasal very small, no loreal; frontal longer than wide; no anterior temporal; large secondary temporal; four supralabials; a black nuchal band bordered with yellow fore and aft; two or three pairs of yellow spots on tail. Ventrals all strongly edged with black, brown or gray; in older specimens most of each ventral scale covered with pigment.

Description of species (from no. 36530, northern Chiang Mai, Thailand): Rostral distinctly wider than high; length of part visible above, about .4 of length of suture between prefrontals; latter scales larger than frontal, touching two supralabials laterally; frontal longer and about twice as wide as supraoculars, longer than its distance from tip of snout, more than one third shorter than parietals; nasal minute, between three scales; a small preocular; a postocular touching four scales; no anterior temporals; a moderately large secondary temporal; four supralabials, fourth nearly quadrangular bordering parietal, very much larger than second; second and third border orbit; vertical diameter of eye equal to or slightly greater than its distance from oral border; five infralabials, first three touching first chinshields which are truncate anteriorly and larger than second

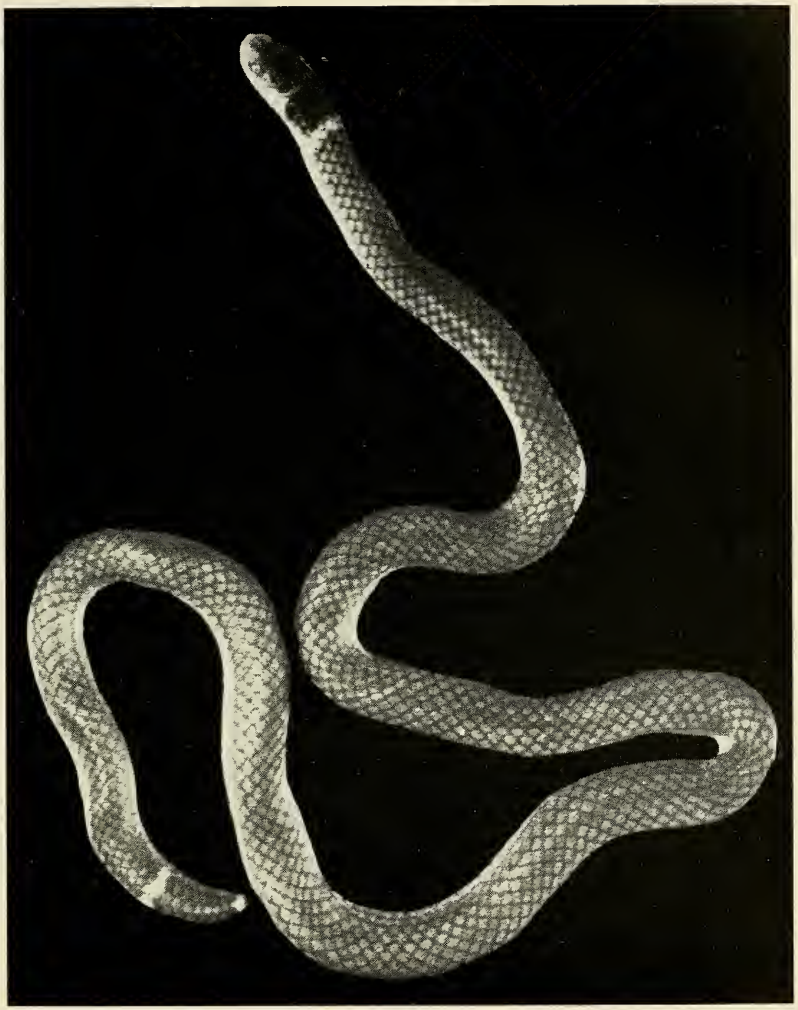

FIG. 47. *Calamaria siamensis* Günther. No. 36530, Doi Suthep, Chiang Mai, Chiang Mai province. Actual total length, 237 mm.; tail 9.5 mm.

pair; latter scales in contact for a very short distance, then separated by a scale.

Scale formula: 17 (occiput), 13, 13, 13. Scales smooth, lacking apical pits. Ventrals, 173; anal, single; subcaudals, 12, divided.

Color: Above dark brown, edges of scales darker than their centers; scale centers under magnification show numerous vermiculate white and brown marks; top of head dark blackish-olive; some

cream-white marks on lower parts of supralabials; a deep black nuchal band with a yellowish mark placed both in front and behind it. Much dark pigment on infralabials with some cream-white marks; distinct yellow areas on sides of head. Ventrals ivory all with some brown pigment forming a bar on each scale, pigment stronger posteriorly; subcaudals similarly marked.

Measurements in mm.: Total length, 237; tail, 9.5; head-width, 4.1; head-length, 5.5; width of body, 4.2.

Remarks: It has been necessary to exhume this species name for this distinctive species occurring in the mountains of northern Thailand.

Measurements in mm. and Scale-counts of *Calamaria siamensis*

NUMBER	36530	36531	3176
Locality	Chiang Mai	Chiang Mai	Chiang Mai
Sex	♀	♀	♂
Total length	237	248	225
Tail	9.5	9.3	9.9
Head-width	4.1	4.1	4.1
Head length	6.3	6.3	6.3
Body-width	4.1	4	4
Preocular	1	1	1
Postocular	1	1	1
Supralabials	4	4	4
Infralabials	5	5	5
Ventrals	173	172	172
Subcaudals	12	11	13

In color and pattern the three are practically identical. The yellow band following the black nuchal band is less distinct in No. 36531. The preocular in all is narrow, and diagonally placed. There are three scales between the second chinshields and the first ventral; and three postparietals between the temporals.

Genus *Ahaetulla* Link

Ahaetulla Link, Beschr. Nat. Samml. Rostock, 1807, p. 73 (type of genus *fasciata* = *Coluber ahaetulla* Linnaeus *(part.)*.

Dendrophis Fitzinger, Neue Class. Rept., 1826, pp. 29, 30, Isis, 1827, p. 519, 520 (type, *Coluber ahaetulla*).

Dendrelaphis Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 339 (type, *caudolineatus*).

Tachyophis Mertens, Arch. Naturg. Berlin, vol. 3, 2, 1934, p. 189 (type *Coluber pictus;* name preoccupied, Rochebrune 1884).

Diagnosis: Maxillary teeth, 20-34, posterior ones smaller or scarcely larger than preceding teeth; head distinct, loreal region

concave; scales smooth in 13 or 15 rows, outer row widened, others narrow, with apical pits, the transverse rows disposed obliquely; vertebral scales enlarged; ventrals with lateral keels on venter, the ventrals notched. Arboreal serpents.

There are five species of this genus in Thailand: *A. ahaetulla, cyanochloris, subocularis, formosa,* and *caudolineata.* They may be distinguished by the following key:

KEY TO THE THAI SPECIES OF AHAETULLA

1. Scales in 13 rows; black longitudinal lines on tail..... *caudolineata*
   Scales in 15 rows..... 2
2. A single elongate supralabial forming lower border of orbit; vertebrals feebly enlarged, narrower than scales of outer row; seven (or more rarely eight) supraoculars..... *subocularis*
   More than a single labial entering orbit..... 3
3. Three or four, rarely two, postoculars present; eye large, as long as its distance from rostral; frontal as long as parietals; nine supralabials, three labials border orbit..... *formosa*
   Two postoculars; three labials border orbit; eye as long as its distance from nostril; vertebrals variable..... 4
4. No stripes on flanks; vertebrals strongly enlarged, larger than outer scalerow; a broad temporal stripe extending on to neck and body... *cyanochloris*
   A yellow or cream stripe on first two scalerows, bordered above and below by a black line; vertebral scales not broader than outer scalerow, *ahaetulla ahaetulla*

These snakes all have a general similarity in appearance and all are excellent climbers.

The nomenclature of this genus has been in dispute for some time. I have accepted the opinion of Dr. J. Oliver* and Dr. Malcolm Smith that the name *Ahaetulla* applies to these Asiatic snakes, rather than to a South American species.

Ahaetulla caudolineata Gray

(Fig. 48)

Ahaetulla caudolineata Gray, Illustrations of Indian zoology, vol. 2, 1834, pl. 81 (type-locality not given).

Leptophis caudolineatus: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 932.

Dendrophis caudolineata: Günther, The reptiles of British India, 1864, p. 297.

Dendrelaphis caudolineatus: Boulenger, The fauna of British India, Ceylon and Burma . . . Reptilia and Batrachia, 1890, pp. 339-340; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 2, 1894, pp. 89-90; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 147; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, p. 213; Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 161 ("Patani"); de Rooij, The reptiles of the Indo-Australian Archipelago, vol.

* Oliver, Bull. Amer. Mus. Nat. Hist., vol. 92, art. 4, 1948, pp. 167-190, 267-272; Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 241. Contrary opinion, Dr. Jay Savage, Bull. Chicago Acad. Sci., vol. 9, 1952, pp. 203-216.

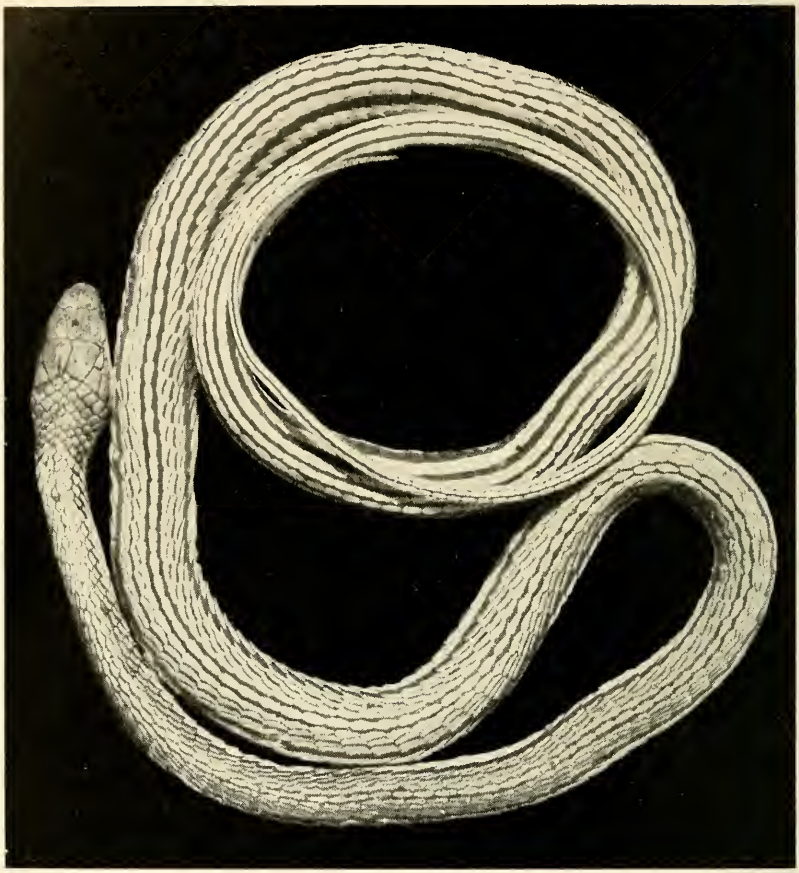

FIG. 48. *Ahaetulla caudolineata* Gray. No. 3478♀, Na Pradoo, Pattani province, southern Thailand. Actual total length, 1183 mm.

2, Ophidia, 1917, pp. 68-69, fig. 36; Sworder, Singapore Naturalist, no. 2, 1922, p. 64; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 52 ("Klong Wan, Tapli, Isthmus of Kra").

Ahaetulla caudolineata: M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 250; Tweedie, The snakes of Malaya, 1954, p. 55.

Diagnosis: Anterior maxillary and mandibular teeth longest. Head distinct from neck; scales in 13 rows disposed obliquely, with apical pits; scales except median and outer rows, elongate, narrow; ventrals with lateral keels.

Description of species (from No. 3478): Rostral once and a half wider than high, very narrowly visible above; internasals narrowed a little in front, about as wide as long; prefrontals broader than long; frontal longer than wide, the sides emarginate, as long as

its distance from tip of snout, shorter than parietals; nasal completely divided; loreal two to three times as long as high; one preocular; supraocular nearly as wide as frontal; two postoculars; temporals, 2 + 2 + 2, anterior ones small, posterior largest; supralabials, 9-9, fifth and sixth bordering orbit; infralabials, 11-11, five anterior bordering first chinshields, which are wider but shorter than second pair; latter separated by scales.

Scalerow formula: 19 (occiput), 13, 11; scales smooth, anterior body scales with single apical pits; ventrals, 177, keeled and notched laterally; anal, divided; subcaudals, 103.

Color: Top of head brown-olive nearly uniform; supralabials greenish yellow with a little black coloration on posterior edges of third and fourth labials; chin and beginning of throat yellowish ivory; anteriorly greenish or greenish gray gradually developing green lines separated by coal-black lines bordering edges of dorsal and lateral scalerows; posteriorly the green gradually turns to greenish or yellowish ivory; a wider green stripe on edges of first and second scalerows bordered above and below by a black line, lower one near twice width of black upper border; five black lines and four yellowish lines on tail. Tail tapering gradually to a fine point. Venter nearly uniform grayish green; posterior edges of ventrals and subcaudals with an indistinct whitish line. A black median subcaudal line.

Measurements in mm. (Nos. 3478, 3917, Na Pradoo, Pattani): Total length, 1183, 1029; tail, 315, 265; width of head, 20, 18; length of head, 33, 27.

Variation: Ventrals vary between 171 and 188; subcaudals, 100 and 112. Boulenger reports a specimen measuring 1520 mm., the tail being 380 mm.

Distribution: In Thailand the species is known only in the peninsula. Specimens have been taken at Na Pradoo, Pattani, Narathiwat, and at Tapli near the Isthmus of Kra. It is a common snake in Southern India, Southern Burma, Malaya and the Indo-Australian Archipelago.

Remarks: The described specimen is from Na Pradoo, Pattani, collected by Nai Prayoon Kananuracks.

Ahaetulla subocularis (Boulenger)

(Fig. 49)

Dendrophis subocularis Boulenger, Ann. Mus. Civ. Sto. Nat., Genova, ser. 2, vol. 6, 1888, Aug. 22, p. 600, pl. 6, fig. 2 (type-locality, Bhamo, Upper Burma); Fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 338.

Dendrelaphis subocularis: Boulenger, Catalogue of the snakes in the British Museum, vol. 2, 1894, p. 89; Smith, Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, p. 785; Proc. Zool. Soc. London, 1921, p. 426; Gyldenstolpe, Kungl. Sv. Vet. Akad. Stockholm, vol. 55, 1916, (3) p. 15; Wall, Rec. Ind. Mus., vol. 22, 1921, p. 159; Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 625; *ibid.*, vol. 30, 1925, p. 813.

Dendrophis tristis subocularis: Meise and Henning, Zool. Anz., Leipzig, vol. 99, 1932, p. 292.

Ahaetulla subocularis: Smith, The Fauna of British India, Ceylon, and Burma; Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 249-250.

Diagnosis: Related to *Ahaetulla ahaetulla* but with the last three or four posterior maxillary teeth shorter and slenderer; no black stripe along edge of ventrals; anterior median series of scales with a row of white dots tending to form a continuous line; a yellow lateral line; vertebral scales scarcely enlarged; scalerows, 15; a single much elongated supralabial under eye.

Description of species (from No. 34972): Rostral wider than high, narrowly visible above; internasals about as long as broad, a little shorter than prefrontals but much smaller, suture between them about as long as that between prefrontals; latter much wider than long, touching loreal, and posterior part of nasal, laterally; frontal longer than its distance to tip of snout, shorter than parietals, its anterior width greater than that of supraocular; parietals touch only upper larger postocular; row of scales following parietals somewhat enlarged; nostril large, between two nasals; loreal elongate touching two labials; supralabials, 7-9 (on right side); five scales precede subocular on left side; only number three, the subocular, touches the two following supralabials; the one following subocular is excluded from temporals; one preocular, two postoculars; temporals, $2 + \frac{1}{2}$, $2 + 2 + 2$; mental much smaller than rostral; 10-11 infralabials, sixth much enlarged, five touching first chinshields, which are larger than second pair.

Scale-formula: 19, 15, 15, 11, median only slightly larger than adjoining rows and definitely smaller than outer row; lateral scales in somewhat oblique transverse rows; scales with single apical pits. Ventrals, 165, each with two keels; subcaudals, 101; anal, divided; 23 maxillary teeth, posterior ones smaller and slenderer than anterior.

Color in life: Head and anterior part of neck dark olive, gradually becoming bronze-brown, which color continues to end of tail, and laterally to middle of second scalerow. A cream or fawn stripe on edges of first and second scalerows below which is a very light bronzy line occupying outer half of row one and and edges of

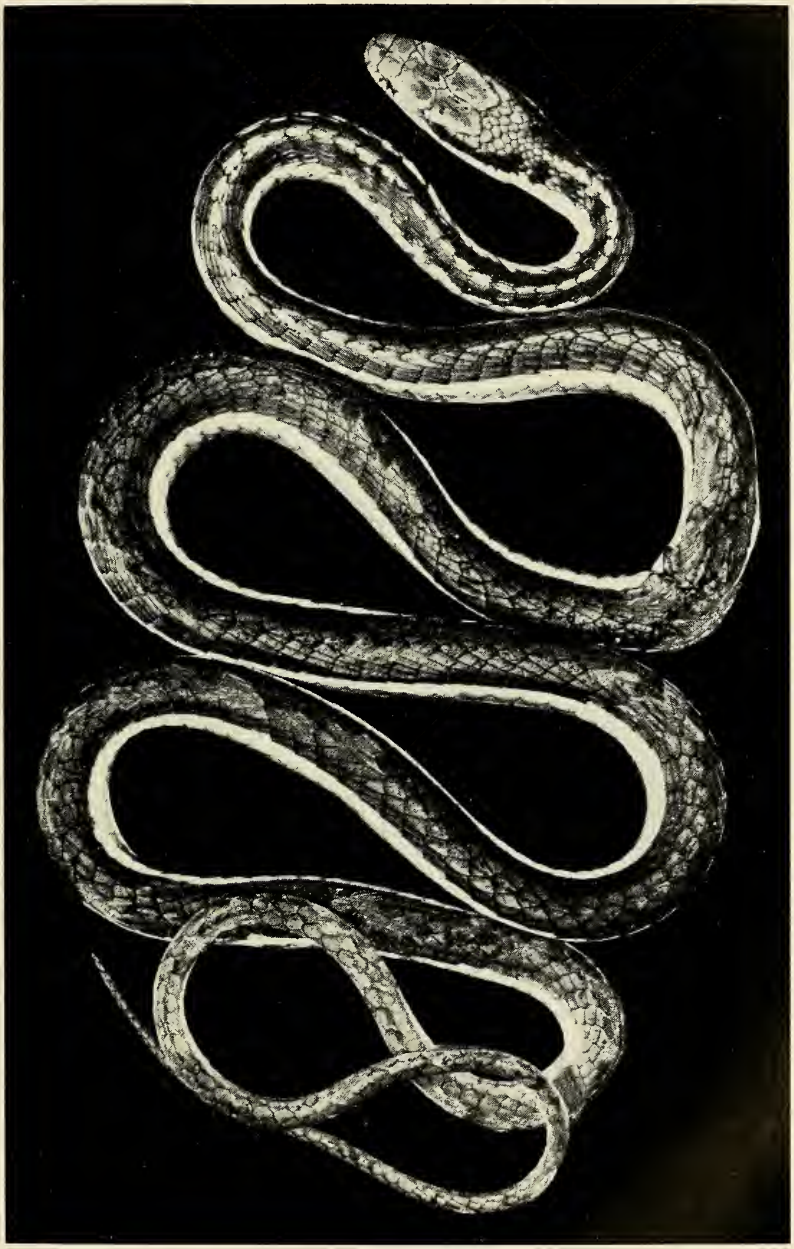

FIG. 49. *Ahaetulla subocularis* (Boulenger). No. 36140, Kaeng Pang Tao, Chiang Mai province. Actual total length, 880 mm.; tail, 234 mm.

ventrals; concealed parts of lateral scales light blue with blackish blotches at each end of blue area; these black spots are not entirely concealed so that diagonal scalerows are edged with a fine denticulate blackish line, less distinct or absent on latter half of body; an indistinct dark line behind eye quickly disappearing on neck; low on sides of neck the light stripe is bluish or dirty white; chin with a faint lavender wash; supra- and infralabials cream, the anterior ones with small black marks on sutures; chin, cream-white with a faint lavender wash.

Measurements in mm.: Length snout to vent, 454; tail, 175; total length 629; head-length, 18.2; head-width, 10.

Variation: Smith records the variation in ventrals as from 153 to 175; subcaudals, 85 to 105.

Remarks: The specimen when captured was crawling on the ground in cut over forest land, the new forest trees about 10-15 ft. high, were scattered. The figured specimen is from northern Chiang Mai province.

Ahaetulla formosa (Boie)

Dendrophis formosus Boie, Isis, 1827, p. 542, (type-locality Java); Flower, Proc. Zool. Soc. London, 1896, pp. 883-884; *ibid.*, 1899, p. 670; Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 2, 1894, pp. 84-85; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 146; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 64.

Ahaetulla formosa: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 52 (*part.*); Sworder, Singapore Nat., no. 2, 1922, p. 64; Tweedie, The snakes of Malaya, 1954, pp. 54-55, pl. 3, upper fig.

Diagnosis: Eye large, equal to its distance from front of nostril; internasals a little longer than prefrontals; frontal as long as parietals; one preocular, two to four, usually three postoculars; temporals, 2 + 2; usually three supralabials bordering orbit; scales in 15 rows; vertebrals considerably larger than scales of outer row; olive, brown, or bronze-brown with reddish and greenish shades; scales edged with black; a black stripe on sides of head, passing through eye, extending on to neck where it widens and converges toward its fellow; two black lines may be present on posterior part of body; venter greenish.

Description of species (from Boulenger, 1912). Eye very large; rostral twice as broad as deep, well visible above; internasals smaller but as long as prefrontals; frontal as long as its distance from end of snout and as long as parietals; loreal much longer than high;

one preocular, and two to four (usually three) postoculars; temporals, 2 + 2; normally nine, rarely eight supralabials, fifth and sixth enter orbit (rarely fourth also); five infralabials touching anterior chinshields which are much shorter than posterior; scales in 15 rows, those of vertebral row considerably larger than those of outer row; ventrals, 174-205; anal, divided; subcaudals, 132-158.

Color: Olive, bronze-brown, or yellowish brown above, with red and green shades; scales edged with black; neck, and sometimes head, red-brown; a black stripe on each side of head passing through eye and extending onto nape, where it widens considerably and converges toward mid-line of neck; two black lines may be present along each side of posterior part of body; upper lip greenish yellow; lower parts greenish.

Measurements in mm.: Total length (largest specimen), 1420; tail, 480.

Distribution: In Thailand this species is confined to the southern peninsular area, specimens having been taken in the provinces Narathiwat, and Yala. Elsewhere the species is present throughout Malaya, and in the islands of Borneo, Sumatra, and Java.

Ahaetulla cyanochloris (Wall)

Dendrophis pictus var. *cyanochloris* Wall, Rec. Ind. Mus., vol. 22, p. 155 (type-locality, Mergui, Tenasserim, Burma).

?*Dendrophis formosus:* M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 161 (see M. Smith, 1943, p. 244-245).

Ahaetulla cyanochloris: M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 482. The fauna of British India . . . Reptilia and Amphibia, vol. 3, serpentes, Dec. 1943, pp. 244-245.

Ahaetulla formosa: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 52 (*part.*). ("Bangnara" = [Narathiwat] and Benang Stah).

Dendrophis pictus: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 337 (*part.*); Catalogue of the snakes of the British Museum, 2nd Ed., vol. 2, 1894, pp. 78-79 (*part. fide* M. Smith).

Diagnosis: A slender arboreal snake, feeding chiefly on the ground. Maxillary teeth, 21-24, teeth increasing in size posteriorly; internasals shorter, or nearly as long as prefrontals; three supralabials bordering orbit, fourth very slightly so or just failing to touch edge of orbit; vertebrals at middle of body wider than scales of outer scalerow. Scales in 15 rows reducing to nine posteriorly. Two anals. A broad temporal stripe extending onto neck where it may break up into spots.

Description of species (data from Wall (1921) and M. Smith 1943): Head moderately separated from neck. Snout a little

broader and more truncate than in *ahaetulla;* eye as long as its distance from middle or front end of nostril; internasals as long as or a little longer than prefrontals; temporals, 1 + 1, or 2 + 2; normally nine, rarely eight or ten supralabials, fourth touching edge of orbit, fifth and sixth bordering orbit; vertebral scales strongly enlarged and at middle broader than scales of outer row, their posterior margins truncate or concave.

Scale-formula: 15, 15, 11 (or 9). Ventrals, 186-211; subcaudals, 135-159; anal divided.

Color in life: Bronze-olive above, scales black-edged; ventrals and outer scalerows pale greenish or yellowish; usually no black stripe on flank; broad black temporal stripe extending onto neck and forepart of body, where it may break into spots; lips and lower jaws yellowish.

Measurements in mm.: (largest), 1330; tail, 405.

Distribution: In Thailand the species occurs in the northwestern part. Outside Thailand it ranges in Bengal, Assam, Upper Burma, Tenasserim, Indo-China and the Andaman and Nicobar Islands.

Remarks: This species, said to very similar in appearance to *ahaetulla ahaetulla,* has fewer maxillary teeth; there is a slight difference in squamation, the width of the middorsal row is greater, the details of the lateral markings are different, and the internasals are longer than the prefrontals. I have not seen a Thai specimen of this species.

Ahaetulla ahaetulla (Linnaeus)

Three subspecies of this widespread form are recognized, but as yet only a single form has been taken in Thailand.

Ahaetulla ahaetulla ahaetulla (Linnaeus)

(Fig. 50)

Coluber ahaetulla Linnaeus, Systema naturae, 10 Ed., 1758, p. 225 (*part.*) (type-locality, unknown); Andersson, Bihang Till K. Sven. Vet. Akad. Stockholm, Band. 24, Afd. 4, 1899, p. 22.

Coluber pictus Gmelin, Systema naturae, Ed. 12, vol. 1, 1789, p. 1116 (type-locality, not given).

Dendrophis pictus: Boie, Isis, 1827, p. 530 (Java); Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 337-338; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 2, 1894, pp. 78-79 (*part.*); de Rooij, The snakes of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 58-60, fig. 34; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1907; p. 189; *ibid.,* vol. 19, 1909-1910, pp. 347, 788; *ibid.,* 25, 1918, p. 509; Rec. Ind. Mus., vol. 22, 1921, p. 153; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914-1915, p. 86, 176, 187, 213; Sworder, Singapore Nat. no. 2, 1922, p. 64; M. Smith, Journ. Federated States Mus., vol. 10,

1922, p. 266; Bull. Raffles Mus., no. 3, 1930, p. 51-52; Meise and Hennig, Zool. Anz., Band, 99, Heft, 11/12, 1932, p. 287; Shaw, Shebbeare and Baxter, Journ. Bengal Nat. Hist. Soc., vol. 14, 1940, p. 108.

Ahaetulla fasciata Link, Beschr. Nat. Samml. Rostock, 1807, p. 74 (based on figure in Bechstein).

Coluber decorus Shaw, General zoology, vol. 3, 1802, p. 538, (type-locality not known).

Ahaetulla bellii Gray, Illustrations of Indian Zoology, vol. 2, 1834, pl. 80, fig. 2 (type-locality, Singapore).

Dendrophis picta andamanensis Anderson, Proc. Zool Soc. London, 1871, p. 184 (type-locality, Andaman Islands).

Dendrophis proarchus Wall, Journ. Bombay Nat. Hist. Soc. vol. 19, 1909-10, pp. 347, 827 fig. (type-locality, Dibrugarh, Assam.).

Ahaetulla boiga: Cochran, Proc. U. S. Nat. Mus., vol. 77, pt. 2, p. 26; (no such species described by Lacépède [see Pope, next entry also], Smith, 1943, p. 241).

Dendrophis boiga: Pope, The reptiles of China . . . 1935, pp. 279-281.

Dendrophis pictus ngansonensis Bourret, Bull. Gen. Instr. Pub. Hanoi, May, 1935, p. 4 (type-locality Ngan-son, Tong-King); Les serpents de l'Indo-Chine, vol. 2, 1936, p. 221.

Ahaetulla picta: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 51.

Ahaetulla ahaetulla ahaetulla: M. Smith, The fauna of British Indian Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 242-244, figs. 10A., 85. Taylor and Elbel Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, p. 1142 (Nakhon Sawan, Thailand).

Ahaetulla ahaetulla: Tweedie, The snakes of Malaya, 1954, p. 54 text fig. l. h.

Diagnosis: Maxillary teeth, 23-28 increasing in length posteriorly. Eye as long as its distance from nostril; internasals shorter than prefrontals; fourth, fifth, and sixth supralabials touch or border orbit; vertebral scales at mid-body not wider than scales of outer row; scales in 15 rows reducing to nine or eleven rows just before vent; a ventrolateral cream or yellowish line bordered by black, which may extend entire length of body.

Description of species (from No. 2, Doi Suthep, Chiang Mai, circa 100 m. elev.): Head slightly distinct from neck; rostral one-and-one-fifth times as wide as high, well visible above; prefrontals large, a little wider than long, smaller and not as long as prefrontals; latter scales one-and-one-half times as wide as long, their suture with loreal and preocular subequal; frontal somewhat bell-shaped, wider than supraoculars, touching preoculars, longer than its distance to end of snout, slightly shorter than parietals; nasal single; loreal more than twice as long as wide; preocular single; two postoculars (three on right, one probably a segment from the fifth labial); temporals, $1+1+2$ $(2+1+2)$; supralabials, 8-9 third, fourth, and fifth (fourth, fifth, and sixth) bordering orbit; eye large, its length equal to its distance from front of nostril; infralabials, 10-10, five touching anterior chinshields which are shorter than posterior; latter in contact with one another for half their length.

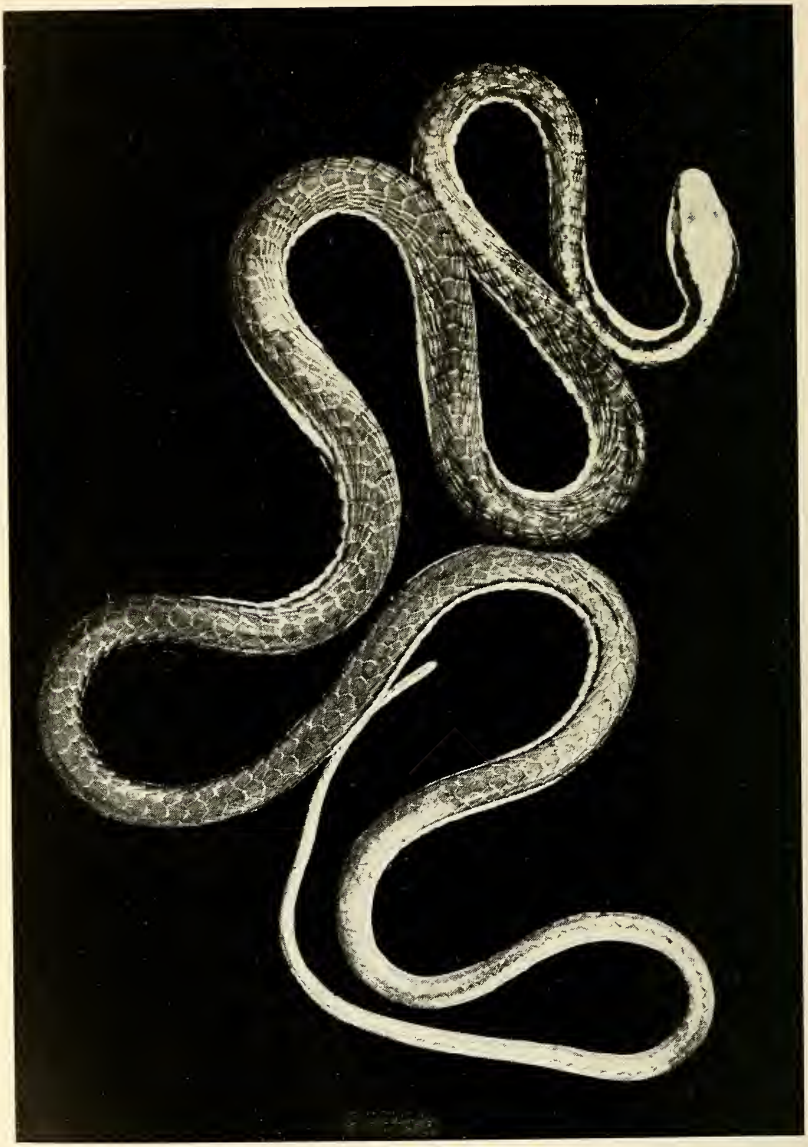

FIG. 50. *Ahaetulla ahaetulla ahaetulla* (Linnaeus). No. 34055, base of Doi Suthep, 5 km. west of Chiang Mai, Chiang Mai province. Actual total length, 781 mm.; tail, 216 mm. (tip missing).

Scalerows: 22 (occiput), 15, 15, 9; scales rather strongly striate, with a single apical pit. Ventrals, 175, keeled on each side and notched at keel; two anals; subcaudals, 143, last three or four likewise keeled and notched. There are 26-25 maxillary teeth, becoming considerably enlarged posteriorly.

Color: Olive-bronze with a black stripe from eye, widening on occiput and passing back along sides of neck where it tends to break up and disappear. Chin and labials cream-white; top of head a lighter bronze-brown than body; a somewhat darker line on sides of snout; sides of body with a diagonal series of dark marks alternating with similar series of scales each with a bluish white mark, most evident on anterior third of body, tending to disappear posteriorly; a light stripe low on sides bordered above and below by a dark stripe. (In preserved specimens the light stripe may be partially obscured, and posterior edges of ventrals appear white).

Measurements in mm.: Snout to vent, 463; tail, 243; total length, 706; width of head 9.2; length of head 18.

Variation: Two other specimens from Thailand are at hand:

No. 689 ♂ Khao Chong, Trang, has 28-29 maxillary teeth; scales reducing to eleven rows posteriorly. Ventrals, 172, subcaudals, 127 + ; anals, 2.

No. 688 ♀ has 25-25 maxillary teeth; ventrals, 180; subcaudals 138; anals, 2. Locality probably Bangkok. This specimen contains six eggs. The scales bear numerous fine striations over most of their surface. (The character of the striae vary, since on the northern specimen the striae are coarser and somewhat fewer in number). The width of the median row of scales varies somewhat in the same specimen. The color characters are important but these tend to disappear in preservatives.

This is not an uncommon snake, however its speed of movement in bushes and trees makes it somewhat difficult to capture. It feeds almost wholly on frogs which it obtains for the most part on the ground. Then it seemingly again returns to shrubs and trees for hiding. Most examples are encountered near water, and especially near rice fields.

The species is oviparous, three to six eggs being laid at one time. Smith (1943) remarks that development of the embryo may begin before deposition. De Rooij (1917) states that they are ovoviviparous. This, probably, is a *lapsus* for oviparous.

Distribution: The species occurs over Thailand in suitable localities and probably could be found in every province. It is also

present in India, Burma, Indo-China, Malaya, the Indo-Australian Archipelago, as far east as the Philippines.

Subfamily NATRICINAE

Genus *Natrix* Laurenti

Natrix Laurenti, Synopsis reptilium, 1768, p. 73 (type of genus, *Natrix vulgaris* = *Coluber natrix* Linnaeus).

The genus *Natrix* has long been regarded as being something of a puzzle, largely because of the diversity of the forms that have been included in it. As understood by many herpetologists it is a composite group consisting of more than a single genus. In my study of Thai species I have been convinced of the wisdom of accepting Fitzinger's genus *Rhabdophis* for natricine snakes with large ungrooved back fangs formerly placed by many herpetologists in *Natrix*. I believe all the American species now considered in this genus are ovoviviparous. At least many of the southeastern Asiatic forms are oviparous.

Malcolm Smith (1943) has declared a relationship between several small Asiatic species and *Natrix modesta*, synonymizing with it certain ones and suggesting that others should perhaps be so regarded. I do not regard this arrangement as acceptable; I also doubt that the group is generically separable from *Natrix* as has been proposed.

Diagnosis: Maxillary teeth, 22-28 (*piscator*); 28-34; posterior teeth gradually enlarged; scalerows, 15 or 19 without nuchal groove or nuchal glands; internasals truncate (*piscator*) or much narrowed anteriorly.

KEY TO SPECIES OF THAI *Natrix*

1. Nostrils lateral; anterior part of internasal a little more than half width of scale, broadly truncate; more than thirty maxillary teeth 2
   Nostrils directed upwards; internasals narrowed anteriorly to about one-third width of the scale; less than thirty maxillary teeth 6
2. Fourth, and fifth supralabials bordering orbit; usually in adults dark reticulations or dark cross-bars enclosing light spots, venter yellow, *percarinata*
   Fourth, fifth and sixth supralabials bordering orbit 3
3. Strong lateral dark spots or bars, usually triangular, the points usually crossing ventrals; a dorsolateral series of light spots may be present, the marks fading with age ..... *trianguligera*
   Not so marked 4
4. Venter with three series of quadrangular dark or black spots forming lines ..... *deschauenseei*
   Not so marked 5
5. Black above with a dorsolateral chain of yellow spots; two outer scalerows with yellow centers; outer edges of ventrals and subcaudals with black spots; ventrals, 147-154, subcaudals, 120-126; anal single .... *groundwateri*

Indefinite gray to brown reticulation with two very narrow light dorsolateral cream lines; labials cream, the color continued as a line diagonally on neck and joining dorsolateral lines; venter yellow, the ventrals with an outer gray or blackish spot . . . . . *inas*

6. Venter yellowish or ivory; outer posterior edge of ventrals grayish or sometimes blackish; diagonal lines from eye absent or very dim; no black diagonal lateral stripe on neck tending to meet its fellow on nape, *piscator*

Each ventral scale with a well-defined complete transverse stripe; two strong diagonal lines from eye, and a lateral nuchal black line, *flavipunctata**

Natrix percarinata Boulenger

Tropidonotus percarinatus Boulenger, Proc. Zool. Soc. London, 1899, pp. 163-164 (type-locality, Kuatun Mts., 3000-4000 ft., NW Fokien, China).

Natrix percarinata: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 201 (Hainan); Rec. Ind. Mus., vol. 42, 1940, p. 483; Parker, Ann. Mag. Nat. Hist., ser. 9, vol. 15, 1925, pp. 302, 304; Pope, The Reptiles of China, 1935, pp. 116-120, pl. 6, figs. F and G; Stejneger Proc. U. S. Nat. Mus., vol. 66, 1925, p. 71 (Szechwan); M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 299. (Southern China, Upper Burma, North Siam [Doi Suthep], Hainan, Tong-King, Annam, and Formosa.)

Natrix annularis: Barbour, Mem. Mus. Comp. Zool., Harvard Coll., vol. 40, 1912, p. 130 (Ichang) (not of Hallowell).

Natrix aequifasciata: Chang, Contr. Biol. Lab. Sci. Soc. China (Zool. Ser.), vol. 8, 1932, p. 33 (not of Barbour).

Diagnosis: Maxillary teeth, 30 to 34. Posterior maxillary teeth gradually enlarged; internasals narrowed anteriorly; nostrils directed slightly upwards; scales in 19 rows, keeled; two anterior temporals; two labials border eye.

Description of species: Rostral twice as broad as high, barely visible above; internasals much longer than broad, narrowed anteriorly, longer than prefrontals; frontal one-and-three-fifths times as long as broad, as long as its distance from end of snout, a little shorter than parietals. Nasal completely divided; loreal as high as wide; one preocular, three postoculars, and a small subocular; temporals, 2 + 3; eight supralabials, fourth and fifth bordering orbit; five infralabials touching anterior chinshields which are shorter than posterior.

Scales in 19 rows; ventrals, 141; anal, divided; subcaudals, 71, paired.

Color: Grayish olive above, sides with light-edged black vertical bars; four anterior supralabials grayish olive as is upper surface

* While I am unable to accept Dr. Malcolm Smith's arrangement of *flavipunctata* as a subspecies of *piscator*, I have followed him in using Hallowell's name for the common variable form occuring throughout Thailand. The type of *flavipunctata* was a rather small specimen, something over 22 inches in length. Hallowell states: "Head small eye somewhat prominent" "eight supralabials the eye resting on the third and fourth." He fails to describe the color and markings of the body save to state "Color dusky yellow with numerous yellow spots along the margins of the scales." "Under parts yellow, the posterior margin of each scute bordered with black."

of head. Rest of head yellowish white like lower surface; venter uniform yellowish white anteriorly, spotted and speckled with black posteriorly; subcaudal area dark gray with some black spots.

Measurements in mm.: Total length, 500; tail, 130.

Variation: Maxillary teeth vary between 30 and 34, the ventrals from 133 to 157; subcaudals 68 to 85. Temporals may be 3 + 3. The scales are strongly keeled, the outer row may or may not be smooth. The young are dark olive green or gray, the color descending on sides as v-shaped bars, often forming complete bands; area between bars yellowish.

Distribution: The species has as yet been taken only in Chiang Mai province on Doi Suthep. It is widely distributed from Burma through Southern China to Hainan and Formosa. One would expect to find the species in all the northwestern provinces.

Remarks: The species reaches a length of 940 mm.; the tail, 270 mm. The species is reported sometimes as brooding the eggs.

Natrix trianguligera (Boie)

(Fig. 51)

Tropidonotus trianguligerus Boie, Isis, 1827, p. 535 (type-locality, Java); Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 224; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 125; Wall, Journ. Bombay Nat. Hist. Soc., vol. 31, 1926, p. 560; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1915, p. 159 (Khoa Wang Hip, Nakhon Si Thammarat; Klong Bang Lai, "Patiyu").

Natrix trianguligera: Smith, Bull. Raffles Mus., no. 3, 1930, p. 43; Barbour, Mem. Mus. Comp. Zool. Harvard Coll., vol. 44, 1912, p. 108; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 84; Sworder, Singapore Nat., 1922, pl. 61; Tweedie, The snakes of Malaya, 1954, p. 68, fig. 15 d.

Diagnosis: Internasals narrowed and truncate anteriorly; nasal divided completely or almost so; one preocular, three postoculars; temporals, 2 + 3; nine supralabials, fourth, fifth, and sixth entering orbit; scales in 19 rows. A broad olive to olive-brown median stripe, spotted or reticulated with gray-black; sides reddish with triangular or subquadrangular spots, the apices on ventrals; venter cream (reddish in life).

Description of species (from No. 20285, Boonsong Lekagul collection): Head distinct from neck; rostral about twice as broad as high; internasals longer than broad, narrowed anteriorly and truncate, the suture between them longer than that between prefrontals; latter broader than long; frontal truncate anteriorly its sides slightly concave, its length greater than its distance to tip of snout, shorter

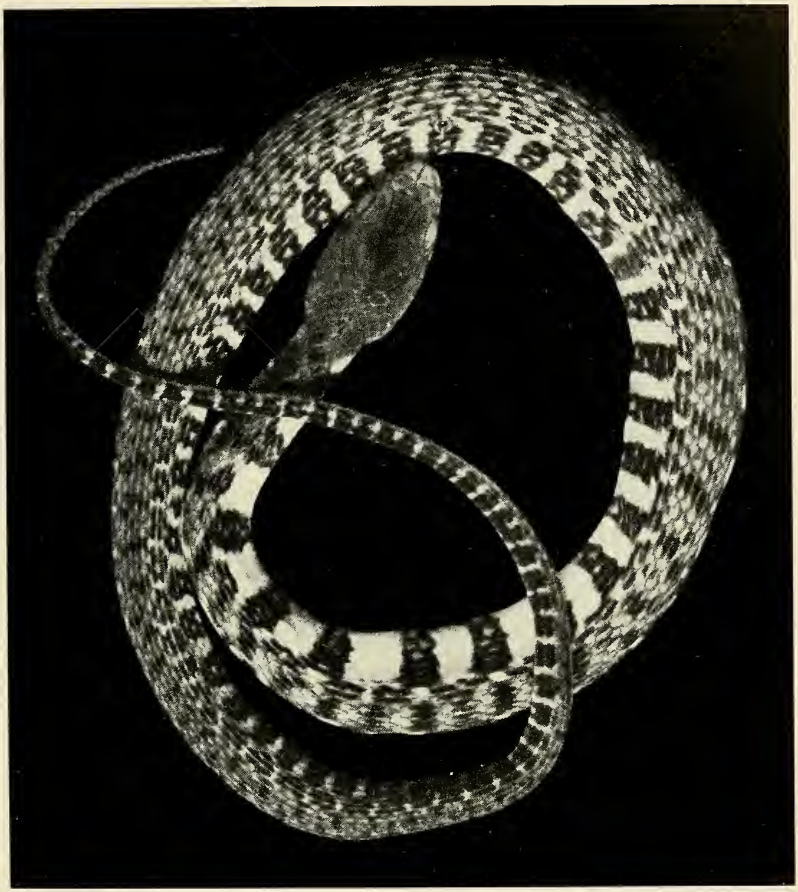

FIG. 51. *Natrix trianguligera* (Boie). P.K. 108, Na Pradoo, Pattani province, southern Thailand. Actual total length, 351 mm.; tail, 110 mm.

than parietals; nasals seemingly completely divided, anterior part largest; loreal approximately as high as long, or a little higher; the single preocular reaches top of head but separated from frontal; three postoculars, upper largest; temporals, 2 + 3; supralabials, 9-9, fourth, fifth, and sixth border orbit; diameter of eye approximately as long as snout; infralabials, 10-10, first five touch first chinshields which are shorter than second pair; latter separated by one or two scales. Scale formula: 21 (occiput), 19, 19, 17; scales strongly keeled except outer row which is usually smooth; ventrals, 138; anal, divided; subcaudals, 88.

Maxillary teeth, 32, last three or four gradually but slightly enlarged.

Color: Head and median part of back (seven or eight scalerows) dark-olive with a tiny pair of black spots on parietals; on back numerous black flecks or spots posteriorly becoming a dim reticulation; sides reddish (faded), with series of vertical black triangles, the apices on ventrals, and each spot showing one or more small light flecks; intervening ground color much wider than triangles anteriorly, but posteriorly they become equal and even smaller; triangles, as they reach ventrals, usually send out processes which may or may not cross ventrals; venter probably reddish (faded to cream); on tail lateral triangular spots almost joined together on underside of tail; labials with black sutures.

Measurements in mm. (Largest known): Total length, 1200; tail, 340.

Variation: The ventrals vary between 134-145, the subcaudals between 86 and 96.

Two young specimens are at hand. These are No. 35586, which I collected at Tonka Harbor Tin Mine, Ronpibon, Nakhon Si Thammarat; and P.K. No. 108 from Na Pradoo, Pattani province collected by Nai Prayoon Kananuraks.

The first specimen (35586) has 43 lateral black spots on the body, 134 ventrals, two anals and 89 subcaudals. The second has 44 lateral black spots, 136 ventrals, two anals and 95 subcaudals. Four is the usual number of postoculars, but the first specimen has only two on the right side. The lateral spots on this specimen are generally triangular but in the second they are nearly quadrangular and from the lower edge of each are two narrow taillike projections that extend onto the ventrals or cross the venter. On the tail the intervening light marks are very narrow and become obsolete toward the tip of the tail.

The second specimen (No. 108) of *Natrix trianguligerus,* from Na Pradoo, varies in certain other characters from the described specimen. The head is moderately slender; the rostral is at least 1½ times wider than high and is visible above as a line. The internasals are narrowed anteriorly and are longer than wide, while the prefrontals are broader then long, their mutual suture shorter than that between the internasals. The frontal is longer than wide, greater than its distance to the tip of the snout, but shorter than the parietals; the supraocular is only slightly less wide than the frontal. The nasal is almost or completely divided, the nostril chiefly in the anterior part. The loreal is higher than long, the preocular preceding it

rather large, reaching the upper surface of snout. Four postoculars are present, the upper largest, touching the parietal. The temporal formula is 2 + 2. There are 9-9 supralabials, the 4th, 5th, and 6th enter the eye, the 8th largest. The diameter of the eye is three-fourths of the length of the snout. The mental is not as wide as the rostral. The infralabials are 9-9, five touching the first chinshields, that are distinctly shorter than the second pair which touch only anteriorly. One pair of scales is present between the second pair of chinshields and the first ventral. The scale-formula: 23 (occiput), 19, 17, 17, all rows keeled except the outer.

Distribution: The species is known from Pattani peninsular Thailand, and it has also been reported from Nakhon Si Thammarat by Malcoln Smith. The specimen here described is from near Ranong, Ranong province at the Isthmus of Kra. The species occurs also in Burma, Malaya, and the Indo-Australian Archipelago.

Natrix deschauenseei Taylor

(Fig. 52)

Natrix deschauenseei Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, pp. 300-302, plate 17, fig. 5, text figs. 2, 3, 4 (type-locality, Chiang Mai, North Thailand).

Natrix modesta: Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 291-292, (*part.*).

Diagnosis: Maxillary teeth, 36, the posterior three or four enlarged but not abruptly so; eight supralabials; scales in 19 rows. Dorsal scalerows, except outer two or three, keeled. Venter with three rows of gray spots.

Description of species (from No. 5, Doi Suthep, Chiang Mai, topotype): Head distinct from neck; rostral a little less than twice as wide as high, narrowly visible from above, truncate posteriorly; internasals narrowed, truncate anteriorly, their length equal or slightly less than that of prefrontals; latter about one fourth wider than long, the longest lateral suture with loreal; frontal shorter than its distance from tip of snout, distinctly shorter than parietals; latter scales distinctly shorter than wide; nostril in a single nasal that shows a partial division below nostril; loreal large, considerably longer than high; two preoculars, upper largest, and two postoculars, parietal touching the upper, the first temporal touching both; temporals, 5 + 2 + 3; supralabials, nine, fifth and sixth border orbit; infralabials, nine, five touching anterior chinshields which are equally as large as posterior; scales keeled except on three outer rows anteriorly, and two outer rows posteriorly.

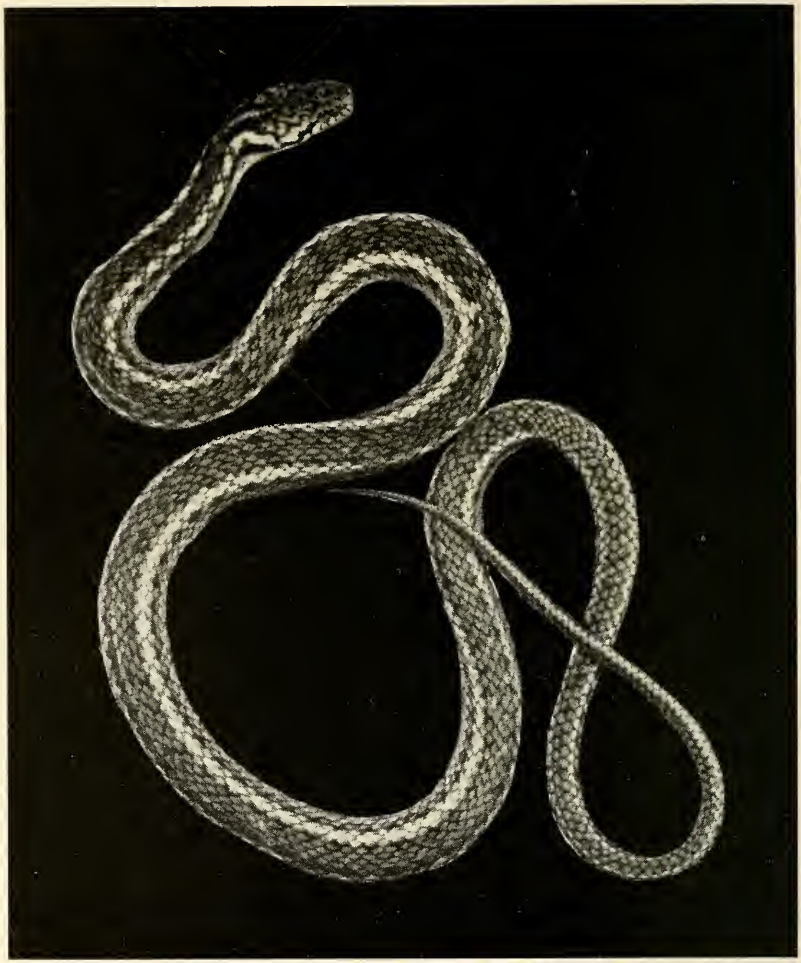

FIG. 52. *Natrix deschauenseei* Taylor. No. 35952, Doi Suthep, Chiang Mai province. About actual size.

Scale-formula: 23 (on occiput), 21 at fourth ventral, 19 at middle of body, 17 on latter part of body; apical pits absent (at least I discern none); ventrals, 159, that preceding the divided anal scale is also divided; subcaudals, 140.

Color in life: Brownish gray, anteriorly with two lighter dorsolateral series of dots or X-shaped spots, separated by ground color, and which farther back form a more or less continuous lighter line covering parts of three scalerows on body, only one on tail; between light lines five median rows have series of very indefinite

dark spots or flecks that may be dimly joined on back but not visible on tail; scales of four outer scalerows with light centers and dark edges; ventrals edged in black making a fine continuous line bordered by a white line. Venter with three rows of brownish gray spots, the median beginning at about eleventh ventral, lateral ones somewhat farther back. As vent is approached, spots cover most of venter; on latter half of body there is a peppering of pigment between spots; subcaudals brownish, scale-edges lighter; outer edge of subcaudals with a continuous light line.

Head variegated brown with indefinite blackish flecks and lines; supralabials light with darker edges, especially the suture between sixth and seventh; a dark line begins behind eye, curves down across eighth and ninth labials with a lighter line above it which joins the dorsolateral line. Chin, throat, and infralabials cream, latter scales with blackish sutures.

Measurement and data on *Natrix deschauenseei*

NUMBER	5	67	68
Total length	480	363	290
Tail	172	124	101
Head width	8	8	6.5
Head length	14	12	11
Supralabials	9	9–9	9–10
Infralabials	9–9	10–10	9–9
Labials entering eye	5, 6	5, 6	5, 6 (5, 6, 7)
Preoculars	2	2	2
Postoculars	2	2	2
Temporals	1+2+3	1+2+3	1+2+3
Ventrals	159	.....	.....
Subcaudals	140	.....	.....

Distribution: Known from type-locality only.

Natrix groundwateri M. Smith

(Fig. 53)

Natrix groundwateri M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4, 1921, pp. 205-206, pl. 8, fig. 2, (type-locality, Tasan 40 km. S. W. Chumphon, ?Ranong province, Thailand); M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, p. 291.

Diagnosis: Small slender *Natrix;* 19 scalerows anteriorly, reducing to 17 at middle of body; scales smooth anteriorly, feebly keeled posteriorly; ventrals, 147-151; subcaudals, 120-126; supralabials, nine, the fourth, fifth, and sixth entering orbit.

Description of species (after M. Smith): Rostral much broader than deep; internasals narrowed anteriorly, as long as prefrontals; frontal one and one-fourth times as long as broad, as long as its distance from end of snout, much shorter than parietals; loreal twice as long as high; two preoculars; two or three postoculars; temporals, 1 + 2; nine supralabials, fourth to sixth touching eye; five infralabials in contact with anterior chinshields which are as long as posterior.

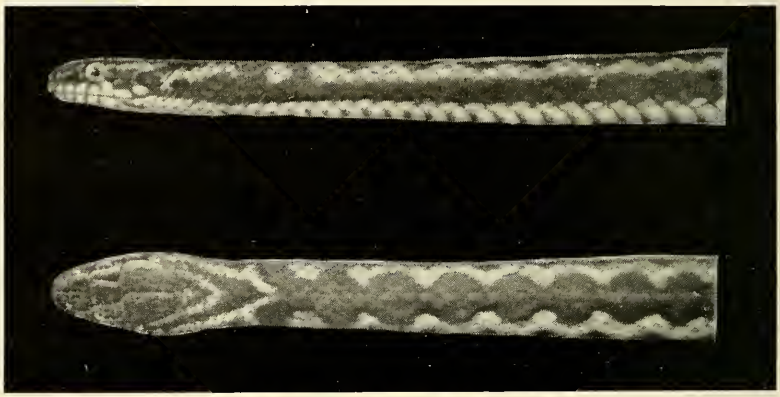

FIG. 53. *Natrix groundwateri* M. Smith. From M. Smith, Journ. Nat. Hist., vol. 4, 1922, pl. 8, fig. 2.

Maxillary teeth 30, last not abruptly enlarged.

Scales in 19 rows anteriorly reducing to 17 at mid-body, and so continued to vent, smooth anteriorly, feebly keeled posteriorly. Ventrals, 147; anal, single; subcaudals, 120, divided.

Color: Black above with a dorsolateral chain of yellow spots connected by a festooned stripe; two outer rows of scales with yellow centers; labials yellow with black sutures, and a yellow streak from angle of mouth to nape; a v-shaped mark behind occiput. Below yellowish, with a black spot at outer edge of each ventral and subcaudal shield.

Measurements in mm.: Total length, 450; tail, 165.

Variation: Four other juvenile specimens taken in the same locality show practically no variation from the type-specimen except in the number of the ventral and caudal scales and in the color of the head which is light brown above, with yellow vermiculations. Ventrals vary between 147 and 151; subcaudals, 120 and 126.

Distribution: Known only from the type locality.

Natrix inas (Laidlaw)

(Fig. 54)

Tropidonotus inas Laidlaw, Proc. Zool. Soc. London, 1901, vol. 2, p. 576, pl. 35, figs. 3 and 4 (type-locality, Gunong Inas, Perak, Malaya); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 125; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 159.

Natrix modesta: (*part.*) M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 290-291.

Natrix inas: M. Smith, Bull. Raffles, Mus., no. 3, Apr. 1930, p. 43 (Nakhon Si Thammarat Mts.); Tweedie, The snakes of Malaya, 1954, pp. 70-71, fig. 17, a, b.

Diagnosis: A slender snake. Ventrals, 143 to 151, subcaudals, 93 to 109. Ventrals with quadrangular dark spots on ends; ventral surface cream-white. Labials with a cream line turning up on sides of neck and continuing dorsolaterally as a series of small indefinite cream spots or as a dim light line. Two or three labials border orbit.

Description of species (from No. 34152): Rostral stands nearly vertical, twice as wide as high, visible above as a black line: Internasals about as wide as long, narrowing anteriorly; prefrontals wider than long, touching loreal, nasal, and preocular, latter forming the longest suture; frontal distinctly longer than wide, six-sided, a little wider anteriorly than posteriorly, longer than its distance from tip of snout, distinctly shorter than parietals; nasal divided, posterior part the larger, touching two supralabials; loreal nearly quadrangular; preocular elongate reaching top of head but not touching frontal; supraocular little more than half width of frontal and somewhat shorter; three postoculars upper largest; anterior temporals, two, the upper a tiny scale; temporals, $2 + 1 + 2$; a series of six scales border parietals behind, the two median scales occupy space in a deep median emargination of the parietals; parietals much narrowed posteriorly; supralabials, nine-nine, fourth, fifth, and sixth border orbit, eighth largest (as if a secondary temporal had been fused to it): infralabials ten, last smallest, first five border first chinshields which are wider but shorter than the slender, posteriorly pointed, second pair; latter separated by a row of three small scales followed by a pair of scales. Eye large, its diameter equal to its distance from nostril.

Scalerow-formula: 23 (occiput), 19, 19, 17; anteriorly at least eight scalerows dimly keeled, posteriorly 15 or 17 rows keeled, the keels of median ones most distinct. Ventrals, 151; anal, divided; subcaudals, 101.

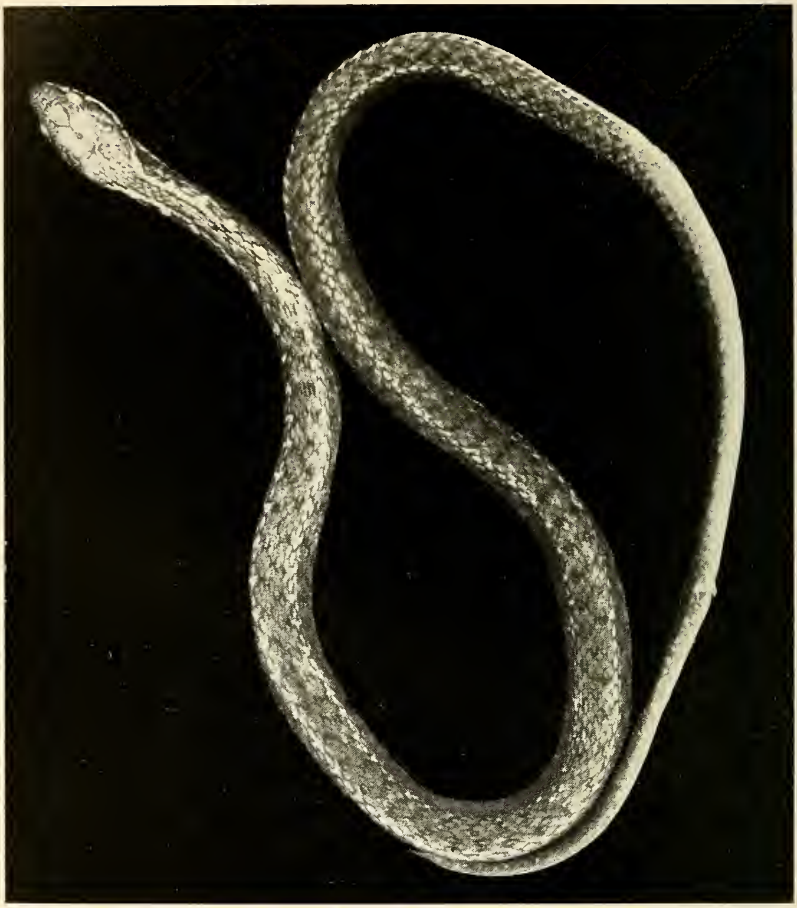

FIG. 54. *Natrix inas* (Laidlaw). B.M. No. 1916.3.27.31, Nakhon Si Thammarat, Thailand. Actual total length, 380 mm.

Color: Above olive-brown with a dorsolateral row of lighter spots anteriorly on fifth, sixth, and seventh scalerows which tend to join and form a continuous row posteriorly on the sixth scalerow; back with indefinite minute paired darker spots, often with a light fleck in center; ventral scales with outer edges dark, bordered below by a narrow cream spot and then a dark spot, the latter forming a broken line on ventrals; median two thirds of ventrals and subcaudals immaculate cream.

Head brown above with darker vermiculations and a pair of small cream spots on middle part of parietals; light cream stripes on upper lips from snout, across angles of mouth, converging, but not meet-

ing, on neck, interrupted by black marks on sutures of anterior supralabials and posteriorly bordered above and below by black. Chin immaculate except for small black marks on sutures of infralabials.

Measurements in mm.: Snout to vent, 333; tail, 169; total length, 502; width of head, 8; length of head, 16.2.

Variation: The type was a much smaller specimen measuring 397 mm. with the ventrals 143, the subcaudals, 96. Laidlaw states "internasal shield broadly truncate, hinder maxillary teeth gradually enlarged." The total known variation in ventrals is 143 to 151; of the subcaudals, 96 to 109.

Distribution: In Thailand the species is known from Nakhon Si Thammarat and Prachuap Khiri Kahn. Outside of Thailand the species ranges in Malaya.

Remarks: The type-specimen was taken in the northern part of Malaya near the base of the mountain Gunong Inas, by Laidlaw and Yapp, at or near Sira Rimau. The specimen here described is presumed to have been taken at Huay Tam Phra, Prachuap Khiri Khan.

The specimen (figured) from Nakhon Si Thammarat, (B.M. 1916.3.27.31) agrees in detail with the markings of the described specimen. In this only two supralabials enter the orbit.

Natrix piscator (Schneider)

(Fig. 55)

Hydrus piscator Schneider, Historiae amphibiorum naturalis et literariae, fasc. primus . . . 1799, pp. 247-258 (type-locality, Coromandel Coast, by inference, the species based on Russell's Indian Serpents, vol. 1, pl. 33 Neeli Koea (Nihli Koeahat [Kuahat] as stated by Schneider).

Tropidonotus piscator (part.) Boulenger, The Fauna of British India, Ceylon, and Burma . . . Reptilia and Batrachia, 1890, p. 349.

Natrix piscator (part.) M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, 1943, pp. 293-298, figs. 95, 96 (Good synonymy and literature list).

This pictured form with the brief description given by Russel is of a snake lacking two black bars extending downwards and backwards from eye and a dark mark on the sides of the neck that is usually continuous with the second black bar; and having groups of small yellowish or cream spots on each side of the dorsum, together with a large number of darker spots often quincuncially arranged, the larger ones anteriorly, the smaller and less distinct ones posteriorly. The venter and subcaudal areas are yellowish white, rather than with black bars on each ventral.

In northern Thailand in Chiang Mai (city), Chiang Mai, there are two species of *Natrix* each about as common as the other, living together in the same pools. One of these I identify as Schneider's *piscator.* The other I regard as *Amphiesma flavipunctata,* which Hallowell originally described from Kwangtung province, China. It is unthinkable to regard them as subspecies of a single species.

The Chiang Mai specimens were acquired by Dr. L. D. Brongersma of the Leyden Museum, and myself, Dec. 5 to 8, 1958, while a tiny swamp, situated some 50 meters back of the Railway Hotel, was being fished before its seasonal drying. Approximately 14 specimens were taken of the larger darker species, agreeing in most details with Schneider's *piscator;* and some 30 specimens of a second species with clearly defined black neck markings, each ventral and subcaudal strongly barred with black. There was no evidence whatever that these forms were intergrading. The first species showed but little variation, while the second one displayed considerable variation in the dorsal pattern and the presence of reddish coloration in some specimens. However, every specimen showed clearly the black marks on ventrals. It cannot be a sexual difference since both males and females are in both groups. That two species are involved I believe there can be no question, despite strong similarity in the structural features. In Dr. Malcoln Smith's treatment of the species *piscator* he seemingly recognizes but a single form occurring in Thailand, which he calls *piscator flaviventris* (Hallowell) and it is certainly the second species mentioned above since he describes it as having the ventrals bearing black bars, and the occasional presence of reddish coloration on the body. The two may be differentiated by the following:

1. Larger snakes often reaching more than one meter in length, larger, usually quadrangular black spots arranged in longitudinal and diagonal rows, becoming smaller and less conspicuous posteriorly; a dorsolateral series of cream or yellow-cream spots covering parts of three or four scales extending more than half length of body; no distinct diagonal black mark on sides of neck; black diagonal marks from eye directed downwards and backwards dim or absent; chin, venter, and subcaudal region yellowish, the outer edges of ventrals grayish..... *piscator piscator*
2. Somewhat smaller snakes not reaching a meter in length; usually a row of vertical black spots on sides touching ventrals with a series of small black spots on back, separate or touching, sometimes forming a reticulum, lacking evident cream or yellow-cream dorsolateral spots but with very small dashlike yellowish marks on scale edges; two black lines from eye distinct, usually the posterior touching a diagonal black stripe on side of neck tending to join its fellow on nape; a pair of small ocelli on parietals and a light black-edged mark on occiput; ventrals each with a narrow black bar except first three or four. Occasional specimens showing considerable red on side of head, neck, and body..... *flavipunctata*

Natrix piscator piscator (Schneider)

Certain subspecific forms of this species probably exist. I believe, however, that *Natrix piscator flavipunctata* of Smith (1943) should be regarded a distinct species from *piscator*. The two forms *piscator* and *flavipunctata* occur often in the same ponds, each maintaining its own specific characteristics without intergradation. The same is equally true of *Natrix asperrimus* * and of a form of *flavipunctatus* in Ceylon.

Since there is no indication of intergradation between the two Thai forms, I propose to treat them as species as has been done by many previous workers. The very large synonymy in the literature suggests much variation in the various populations and makes evident the difficulty of placing names and references without examination of the specimens on which the names were based. The table shows their similarities.

Diagnosis: See key above.

Description of species (from M. 34947, Phu Kading, Loei Prov.): Rostral one-and-one-third times as wide as high; internasals narrowed to one third of their width anteriorly, distinctly shorter than prefrontals; latter very little wider than long, suture with nasal very short; frontal longer than its distance from end of snout, one sixth shorter than combined parietals; nasal divided, anterior part much the larger, nostril near upper border of anterior part; loreal longer than high; one large preocular reaching top surface of head; three postoculars, the subocular the largest, almost reaching to below middle of pupil below eye. Temporals, 2 + 3; supralabials, 9-9, fourth and fifth bordering orbit rather narrowly; length of eye less than its distance from nostril; infralabials, 10-10, first five touching first chinshields which are shorter than second pair; latter separated by small scales.

Scale-formula: 24 (occiput), 19, 19, 17; farther back on neck median scales lightly keeled, five outer rows smooth (posteriorly only four or three rows smooth); scales not narrowed and elongated.

Ventrals, 132; subcaudals, 80; anals, 2. Maxillary teeth, 23, gradually increasing in size posteriorly.

Color: Olivaceous above with black spots quincuncially arranged, the spots in five or seven rows anteriorly but more or less connected by a dim reticulum; a row of cream or yellowish dots on

* See Taylor, Univ. Kansas Sci. Bull., vol. 33, pt. 2, 1950, pp. 567-659, pl. 15, fig. 2, and pl. 21, fig. 1.

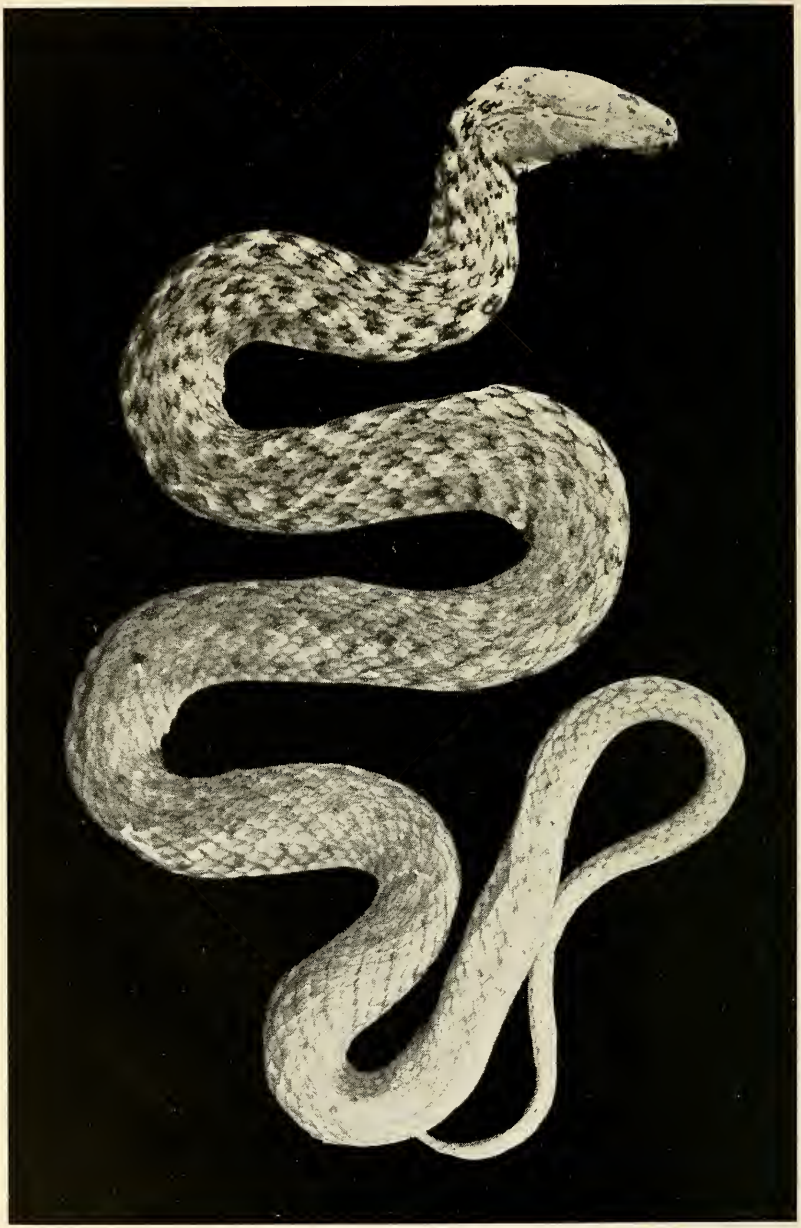

FIG. 55. *Natrix piscator piscator* (Schneider). No. 33843, Chiang Mai (city), Chiang Mai province, northern Thailand. Actual total length, 776 mm.; tail, 215 mm.

each side disappearing or becoming very dim beyond middle of body; labials dirty white with considerable pigment; a pair of diagonal lines from eye extend to mouth, the posterior reaching angle of mouth; area between these lightly pigmented. Chin, infralabials, entire venter and subcaudal region, cream-white; lateral border of ventrals grayish; lateral edges of subcaudals blackish, forming fine zigzag lines.

Measurements in mm.: Total length, 844; tail, 264; width of head, 22; length of head, 37.

Variation: A female specimen from Phu Kading Loei province differs a little from the preceding description as follows: the prefrontals are narrowed to about one half of their width; the anterior nasal is only slightly larger than posterior; the eighth labial is crowded out of the labial row by contact between ninth and seventh on border of mouth. There is a single elongate temporal followed by two secondary temporals. Ventrals, 144; subcaudals, incomplete, tip of tail missing.

The yellow lateral dots are often confined chiefly to interstitial skin and unless the skin is stretched, are not completely visible. The venter is immaculate save for a very narrow vague edging of gray on the outer part of ventrals.

Distribution: In Thailand this species seemingly is confined to the northern part. It is very common about Chiang Mai as is another form, *flavipunctata*. In the small pond just back of the Railway Terminal Hotel in Chiang Mai, approximately 30 specimens of *Natrix flavipunctata* and 14 *piscator* were obtained by Dr. L. D. Brongersma and myself in December, 1957.

Natrix flavipunctata (Hallowell)

(Fig. 56)

Amphiesma flavipunctatum Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 503, (type-locality, Canton River, Kwangtung, China).

Natrix piscator flavipunctata: M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 296; Taylor and Elbel, Univ. Kansas Sci. Bull.; vol. 38, pt. 2, 1958, pp. 1151-1152, (Khon San, Chaiyaphum province, Thailand).

Diagnosis: Scales weakly keeled anteriorly on all save three smooth outer rows (more posteriorly two rows or one without keels); posteriorly the keels are strongly developed; anteriorly internasals narrowed to about one third of their greatest width; fourth and fifth labials entering eye; temporals, 2 + 3; scales in 19 rows at middle. Ventrals and subcaudals each with a distinct black

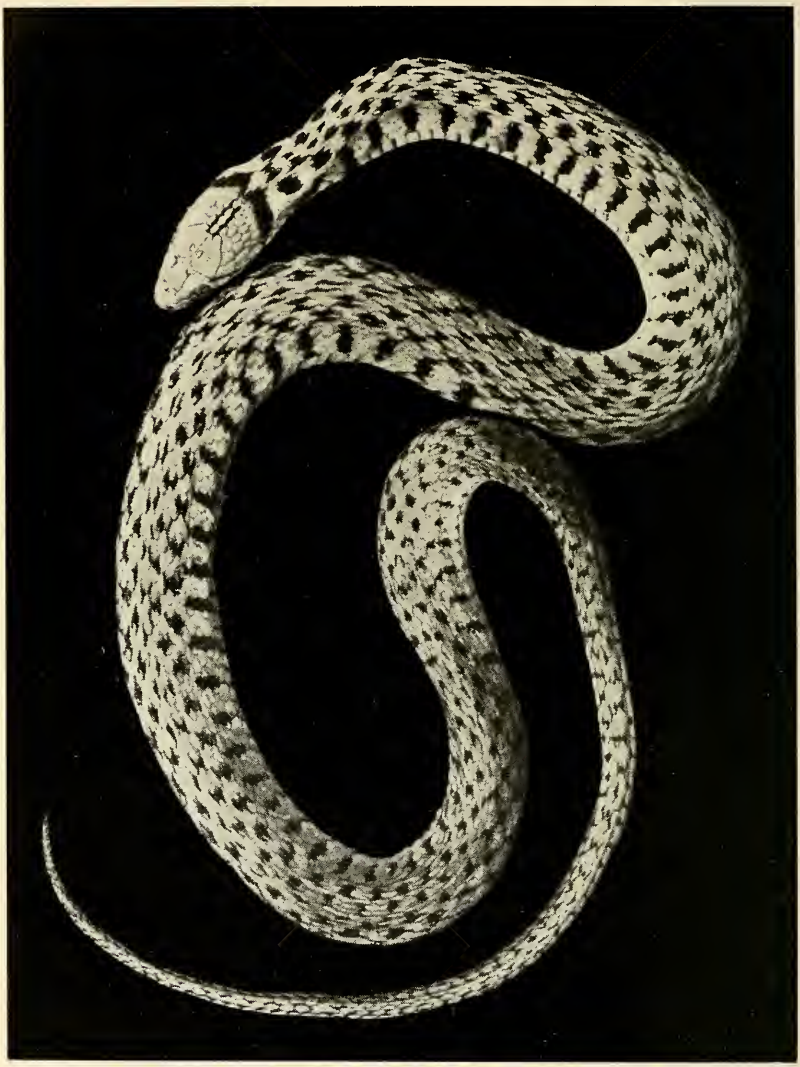

FIG. 56. *Natrix flavipunctata* (Hallowell). No. 33406, Chiang Mai (city), Chiang Mai province, northern Thailand. Actual total length, 701 mm.; tail, 197 mm.

posterior border; series of small dashlike diagonal yellow spots present on sides.

Description of species (from No. 78 ♀ Chiang Mai [city]): Rostral twice as wide as high, narrowly visible above; internasals narrowed to one third of their width anteriorly, a little shorter than prefrontals; latter only slightly wider than long; frontal slightly

widest anteriorly, sides concave, longer than its distance from end of snout, little shorter than parietals; nasal completely or almost completely divided, anterior part somewhat the larger; loreal a little longer than high, touching three anterior supralabials; one preocular barely reaching upper surface of head; three postoculars, upper as large as lower, latter not reaching down on side of head as far as middle of pupil. Two anterior temporals, upper the smaller, three secondary temporals not well aligned; supralabials eight, fourth and fifth border orbit, sixth and seventh largest; eye slightly shorter than its distance from nostril; infralabials ten, five bordering first chinshields which are shorter than second pair; latter separated by small scales.

Scale-formula: 24 (occiput), 19, 19, 17, all keeled except three (two or one posteriorly) outer rows, rather weakly keeled anteriorly, but becoming stronger posteriorly. Ventrals, 132; subcaudals, 77; anal, divided.

Color in life: Head dark olive, the labials lighter. Two black parallel lines from eye directed downward and backward; space between dark lines, yellow or yellow-olive; two black lines from mouth angles converge on neck (or narrowly fail to touch); two tiny median black parallel lines on occiput. Body olive with black spots anteriorly, distinct laterally, rather obscure dorsally, but soon all more or less commence forming a reticulum, less distinct posteriorly; spots on tail absent or obsolete; venter greenish white, each ventral scale with a distinct black line on its posterior edge, and many body scales with small dashlike yellow marks.

Measurements in mm.: Total length, 567; tail, 164; width of head, 14; length of head, 24. The species reaches a length of 1200 mm.; the tail, 300 mm. (see table).

Distribution: The species is widely distributed in Thailand. Specimens are at hand from northern Chiang Mai. Chaiyaphum, Ubon, and Phattalung provinces, and the city of Bangkok. It is one of the commonest species in the country. Outside Thailand the species is found in southern China, India, Indo-China, Assam and northern Malaya.

Remarks: A large female specimen captured in the city of Bangkok contained 60 embryos.

Genus *Opisthotropis* Günther

Opisthotropis Günther, Ann. Mag. Nat. Hist., ser. 4, vol. 9, p. 16 (type of genus, *O. atra*); Pope, The reptiles of China, Nat. Hist. Cent. Asia, vol. 10, 1935, pp. 164-166.

Table of data and measurements of *Natrix piscator* and *Natrix flavipunctata*

NUMBER	Sex	Ventrals	Sub-caudals	Pre-oculars	Post-oculars	Tem-porals	Supra-labials	Infra-labials	Total length	Tail
33839.....	♀	143	63+	1—1	3—3	2+3	9—9	10—10	773	186+
33840.....	♀	140	79	1—1	3—3	2+3	9—9	10—10	714	196
33842.....	♀	143	80	1—1	3—3	2+3	9—9	10—10	660	180
33843.....	♀	144	77	1—1	3—3	2+3	9—9	10—10	776	215
34058.....	♀	142	78	1—1	3—3	2+3	9—9	10—10	594	167
31808.....	♂	135	93	1—1	3—3	2+3	9—9	10—10	830	268
31809.....	♂	146	87	1—1	3—3	2+3	9—9	10—10	541	159
31810.....	♀	144	75+	1—1	3—3	2+2+2 2+2 2+3	9—9	10—10	1108	294
26.....	♂	131	80	1—1	3—2	2+3	9—9	10—10	843	257

Natrix flavipunctata

NUMBER	Sex	Ventrals	Sub-caudals	Pre-oculars	Post-oculars	Tem-porals	Supra-labials	Infra-labials	Total length	Tail
33406.....	♀	135	77	1—1	3—3	2+3	9—9	11—10	701	197
33823.....	♀	143	77	1—1	3—3	2+3	9—9	10—10	765	195
33824.....	♀	141	40+	1—1	3—3	2+3	9—9	10—10	546	88+
33846.....	♂	127	82	1—1	3—3	2+3	9—9	10—10	607	183
33848.....	♀	139	74	1—1	3—3	2+3	9—9	10—10	747	190
33849.....	♀	144	72	1—1	3—3	2+3	8—8	10—11	624	152
33856.....	♂	131	84	1—1	3—3	2+3	8—8	8—9	662	194
34897.....	♀	141	.....	1—1	3—3	2+2 2+3	9—9	10—10	.....	.....
34898.....	♂	129	.....	1—1	3—3	2+3	9—9	10—10	.....	.....
35900.....	♂	125	74+	1—1	3—3	2+3	9—9	10—10	547	161

Note. Numbers between 33823—33858, and 26, are from Chiang Mai; 31808-10 from Loei: 34897-35900 Ubon, Ubon.

This genus has had a series of generic increments at the hands of several authors; no less than six genera proposed in the last century have been added to it by Pope, and two by Malcolm Smith.*

Few genera, so recognized, have a more remarkable range in maxillary tooth-count. One group of species has the count between 22-27, while another species jumps the count from 36-42.

Only a single species is known from Thailand—this a mountain form from northern Chiang Mai, province.

Diagnosis: Paired internasals; fused prefrontals; frontal nearly as wide as long and about four times as wide as supraocular; loreal present; internasals broader than long; scales smooth in 17 rows; parietals distinctly longer than their distance to end of snout; first five supralabials higher than long.

Opisthotropis spenceri Smith

Opisthotropis spenceri Smith, Journ. Nat. Hist. Soc. Siam, vol. 3, no. 1, Nov. 1918, p. 13; pl. 2 (type-locality, "Muang Ngow, N. Siam"); The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 333, (known from 2 specimens both from the type-locality); Pope, The reptiles of China, Nat. Hist. Cent. Asia, vol. 10, 1935, p. 165; Bourret, Les serpents de l'Indochine, pp. 129-130, fig. 53.

Diagnosis: Scales in 17 rows; prefrontal single; loreal in contact with internasal; seven supralabials, fourth and fifth entering orbit; frontal four times wider than supraocular; first chinshield much larger than second; no enlarged posterior fangs.

Description of species (from type description): Snout broadly rounded, much depressed; nasal almost completely divided by a cleft running from internasal towards first labial; rostral nearly twice as broad as deep, well visible from above; internasals subtriangular, a little broader than long; prefrontal single, large, two and a half times as broad as long; frontal large, slightly longer than broad, as long as its distance from rostral, nearly four times as broad as supraocular; loreal a little longer than deep, in contact with internasal; one preocular, two postoculars; temporals, 1 + 2 or 2 + 2; seven supralabials, fourth and fifth entering orbit; five infralabials in contact with chinshields, the anterior pair of which is very much larger than posterior.

Scales in 17 rows throughout, entirely smooth, ventrals, 183; anal divided; subcaudals, 33 +. The maxillary teeth, 25; palatine, 14; pterygoid, 18; mandibular, 22.

* These are *Calamohydrus* Boulenger 1888, *Helicopsoides* Mocquard 1890, *Trimerodytes* Cope 1895; *Tapinophis* Boulenger 1899, *Liparophis* Peracca 1904; *Cantinophis* Werner 1909, *Paratapinophis* Angel 1929, and *Parahelicops* Bourret 1934.

Color: Olive above, pale yellowish beneath, the colors mingling on three outer rows of scales. Subcaudals mottled with gray.

Measurements in mm.: Total length, 600; tail (imperfect), 72.

Remarks: A single female collected in September 1917 served for the type-description. A second specimen has been found in the type-locality.

Whether this species is correctly referred to this genus may be open to question, since *Opisthotropis* is presumably an African genus. It would seem however that, since the type was described, it has not been rediscovered in Africa. This would possibly throw grave doubts on the African origin except that the type species seemingly has not, to my knowledge, been discovered elsewhere.

Genus *Parahelicops* Bourret

Parahelicops Bourret, Bull. Inst. Pub. Gen. Hanoi, May, 1934, p. 170, (type of genus, *P. annamensis*).

Diagnosis: Natricine snake with 25-30 maxillary teeth, last two or three are enlarged ungrooved fangs; no apical pits; hypapophyses developed throughout vertebral column; scales keeled, in 17 or 19 rows; anal double or single; prefrontals fused into a single scale.

Only two species are recognized, a single one being known in Thailand.

This genus has been placed in *Opisthotropis* by Pope in 1936 and was followed by M. Smith in 1943—a synonymy which I do not follow. The type of the latter genus is said to be African in origin, and the dentition of *Opisthotropis* is—maxillary teeth 20 to 25, small, equal, a difference certainly of generic significance.

Parahelicops boonsongi Taylor and Elbel

(Fig. 57)

Parahelicops boonsongi Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, no. 13, Mar. 20, 1958, pp. 1156-1158, fig. 31, (type-locality, Ban Khok, Na Phung, Loei province, Thailand).

Diagnosis: A natricine snake, the scales in 19 rows, all strongly striate and keeled; a single prefrontal; two suboculars; above nearly uniform gray-olive in coloration, growing lighter on the sides; venter cream-white; a median gray subcaudal line (at least at base of tail).

Description of species (from the type-description): Rostral once and a half as wide as high, very narrowly visible above; internasals elongate, narrowed and truncate anteriorly, rounded posteriorly, their length slightly greater than length of prefrontal; latter twice

as wide as long; frontal five-sided, slightly wider anteriorly than elsewhere, a little shorter than supraoculars, equal to its distance from rostral, a third shorter than parietals; nasal elongate, partly divided by a suture from nostril to second supralabial; loreal as high as long; a large preocular not reaching frontal; two or three postoculars; two suboculars, the anterior reaching beyond middle of eye; temporals, 2 + 3 + 4; nine supralabials, first three touching nasal, third only touches loreal, fourth and fifth entering orbit, seventh largest; mental wider than long, as wide as rostral; infralabials ten, five touching first chinshields which are distinctly shorter than second pair; latter pair separated by scales, narrowly so anteriorly.

Scalerow formula: 25 (occiput), 19, 19, 17, all keeled except anterior part of outer row, which is smooth but faintly keeled posteriorly; posterior edges of scales notched (bidentate), bearing a fine transparent fringe.

Ventrals, 141; anals, 2; subcaudals 33 + (tail broken and part lost). Eye rather large, its diameter equal to its distance from nostril; pupil round. Maxillary teeth 30, the last three suddenly much enlarged, but not grooved.

Color: Nearly uniform gray-olive above, growing a little lighter laterally, becoming nearly cream-white on outer two or three scalerows anteriorly on side of neck; posteriorly outer two scalerows and to some extent outer edge of ventrals, with some grayish pigment; supralabials and suboculars cream; an indefinite fumate spot back of jaw-angle; venter generally cream-white; subcaudal region with a median gray line and many scales with an indefinite pigmented area. When specimen is submerged in clear liquid it is possible to discern dimly some indefinite darker areas on anterior half of body.

Measurements in mm.: Snout to vent, 520; tail 101 +; total length, (part of tail missing) 621 +; length of head, 26; width of head, 18; width of neck, 13.

Remarks: The species is still known only from the type. It is presumed to be a northern form that has entered Thailand from the northwest but has not penetrated far. It should be looked for in the mountains of Laos and Yunnan.

Genus *Pseudoxenodon* Boulenger

Pseudoxenodon Boulenger, The fauna of British India, including Ceylon, and Burma . . . Reptilia and Batrachia, 1890, pp. 340-341 (type of genus, *P. macrops*).

FIG. 57. *Parahelicops boonsongi* Taylor and Elbel. Type. EHT-HMS No. 31707, Ban Khok, Na Phung, Dansai, Loei province. Actual total length, 621 + mm. (From Taylor and Elbel.)

Diagnosis: Head moderately distinct from neck; eye large, pupil round; body cylindrical; scales obliquely disposed, keeled, lacking apical pits, in 17 to 19 rows. Ventrals rounded, subcaudals double. Maxillary teeth, 20-28, increasing in size posteriorly, last two abruptly enlarged and separated by a short diastema from others.

Only one species has been captured in Thailand, a wide-spread form whose range extends from the Eastern Himalayas of Nepal to Northern Thailand and Annam; south to the northern part of the Malay Peninsula. It is not known whether or not the distribution is continuous in Thailand. Seemingly no specimens have been taken between northern Thailand and northern Malaya. It is however known throughout Burma and is doubtless present in Thailand in the border highlands.

Pseudoxenodon macrops (Blyth)

(Fig. 58)

Tropidonotus macrops Blyth, Journ. Asiat. Soc. Bengal, vol. 23, 1854, p. 296 (type-locality, Darjeeling, India).

Some two or three forms have been described that are probably subspecies of *macrops* (*sinensis, uniformis*), only one of which, the typical form, appears to enter Thailand.

Pseudoxenodon macrops macrops (Blyth)

Tropidonotus macrops Blyth, Journ. Asiat. Soc. Bengal, vol. 23, 1854, p. 296 (type-locality, Darjeeling, India); Stoliczka, Journ. Asiat. Soc. Bengal, vol. 40, 1871, p. 436.

Pseudoxenodon macrops Boulenger, The fauna of British India, including Ceylon, and Burma . . . Reptilia and Batrachia, 1890, pp. 340-341; Catalogue of the snakes in the British Museum, vol. 1, 1893, pp. 270-271; Venning, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910-11, p. 340, 772; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 321; *ibid.*, vol. 19, 1909, pp. 341, 898; Smedley, Bull. Raffles Mus., no. 5, 1931, p. 51; Pope, The reptiles of China, Turtles, Crocodilians, Snakes, Lizards, in Natural History Central Asia, vol. 10, 1935, pp. 151-153 (subspecies); M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 484; The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 311-313. Tweedie, The snakes of Malaya, 1954, p. 73 (Cameron Highlands, Malaya).

Pseudoxenodon macrops macrops:[*] Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, no. 13, Mar. 20, 1958, p. 1149, fig. 29 (Ban Muang Khai, Ban Khok, Loei Province).

Tropidonotus sikkimensis Anderson, Journ. Asiat. Soc. Bengal, vol. 40, 1871, p. 17 (type-locality, Darjeeling, India).

Tropidonotus angusticeps Blyth (*part.*), Journ. Asiat. Soc. Bengal, vol. 23, 1854, p. 295 (type-locality, Darjeeling, India); Sclater, Journ. Asiat. Soc. Bengal, vol. 40, 1891, p. 240.

Pseudoxenodon angusticeps: Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 608; Bourret, Les serpents de l'Indochine, 1936, p. 111; Shaw, Shebbeare, and Barker, Journ. Darjeeling Nat. Hist., Soc., vol. 13, 1939, p. 151.

Diagnosis: Medium-sized snake reaching a little more than one meter in length; two nasals, one preocular, three postoculars; eight supralabials, two entering orbit; scales in 19, (19-17), 15 rows, keeled. A series of yellowish to orange transverse or oblique dorsal

[*] *Pseudoxenodon macrops sinensis* has been described from Yunnan Fu.

spots bordered by black. Head uniform olive-brown with a broad black chevron on neck preceded by a narrow orange chevron, and followed by a broader light (yellow to orange) chevron; one or two series of small lateral dark spots; anterior part of venter strongly marked with black, posterior part immaculate or clouded.

Description of species (from No. 683): Rostral about one fourth wider than high, well visible above, rounded posteriorly; internasals wider than long; prefrontals one-fifth wider than long; frontal longer than its distance from tip of snout, shorter than a parietal; latter, one third longer than wide; nasal divided; loreal as long as

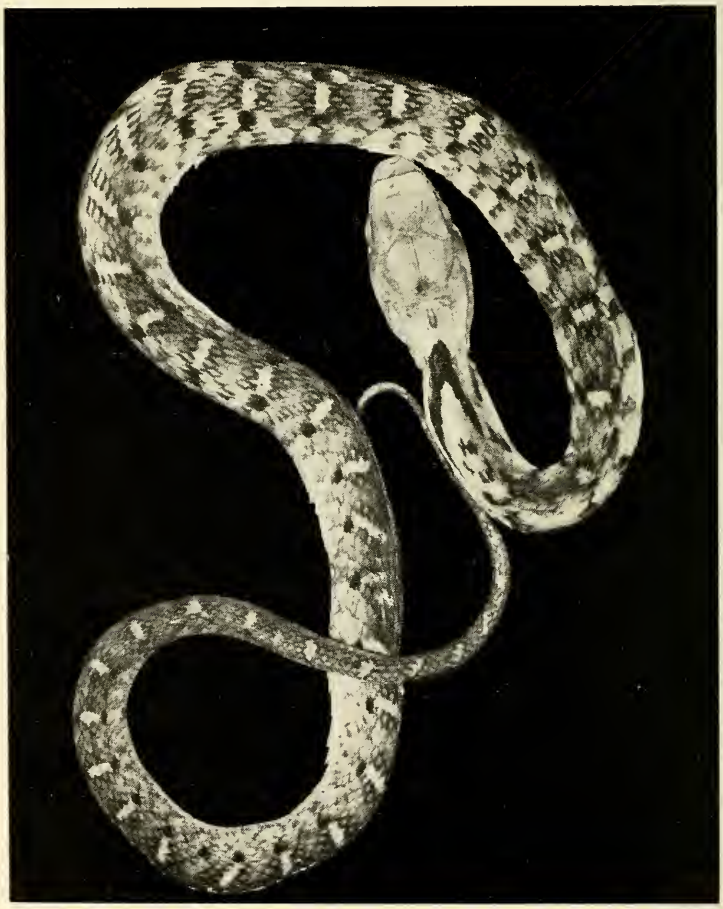

FIG. 58. *Pseudoxendon macrops macrops* Blyth. EHT-HMS No. 31704, yg. Phu Nam Lang (Mt.) 1780 m., Ban Khok, Na Phung, Dansai, Loei province Central Thailand. Actual total length, 263 mm. (Note the head is proportionately large in the young.) From Taylor and Elbel.

high; two preoculars, upper largest, barely reaching top of head; three postoculars, upper touching parietal, both touching a single anterior temporal; temporals irregular; large temporal behind anterior temporal bordering parietal; eight supralabials, fourth and fifth border orbit, seventh much the largest; diameter of eye equal to length of snout; infralabials, 10-9; four or five touching first chinshields which are as long as second pair.

Maxillary teeth, 24-25, increasing a little in size and followed after a diastema by two enlarged fangs, directed backwards. Scale-rows: 21 (occiput), 19, 19, 15; ventrals, 169; anal, divided; subcaudals, 67.

Color (in preservative): Head grayish brown, little lighter on tip of snout; labials cream except that between seventh and eighth there is a black line; infralabials, chin, and anterior part of throat cream; a narrow light nuchal chevron reaches almost to parietals, followed by a broader chevron of deep black; this followed in turn by a light chevron; body with a series of dorsal light (orange) spots rather longer than wide anteriorly, narrower and sometimes obliquely placed, wider than long more posteriorly; farther back on tail becoming as long as wide; 30 spots on body, 12 on tail; these preceded and followed by gray-black with a rather discrete dark-black mark on either side; low on sides another row of dark spots; centers of scales involved but lighter on centers; venter cream anteriorly with heavy black marks that grow smaller and less numerous and light brown in color on second third of body; last third dirty cream with only very indefinite marks; a slightly dark median subcaudal line tending to disappear posteriorly.

Measurements in mm. (Nos. 683 and 34151): Total length, 546, 618; tail, 98, 113; width of head, 11.8, 15; length of head, 21, 22.

Variation: Another specimen, No. 34151, agrees with or differs from the above as follows: The rostral is angular behind; the frontal shorter than the distance to the tip of snout; a loreal much higher than wide; one preocular, three postoculars; two anterior temporals; posterior chinshields longer than anterior. Another specimen in the collection (without number) has the scale formula, 25, 19, 15, 15. There are 159 ventrals and 69 subcaudals; there are 30 spots on the body, 14 on the tail. Two specimens from Loei province reported by Taylor and Elbel have, 171, 174 ventrals; 63, 67 subcaudals respectively.

Distribution: Thailand specimens are known from Loei province and from Pa Meang, Chiang Mai province in the northwestern part of the country.

Remarks: One Loei specimen 882 mm. in length, has 10 ovarian eggs. The specimen described is from an unknown Thai locality.

Genus *Macropisthodon* Boulenger

Macropisthodon Boulenger, Catalogue of the snakes in the British Museum (Natural History), 2nd Ed., vol. 1, 1893, p. 265, fig. 17 (type, *Macropisthodon flaviceps*).

Diagnosis: Head distinct from neck; eye medium in size, with round pupil; scales strongly keeled, in 19 to 27 rows. Apical pits; ventrals rounded; subcaudals paired. Maxillary teeth 11 to 18 after a short hiatus two large ungrooved fanglike teeth, pointing backwards. Hypapophyses present throughout.

The genus has two of its four representatives in Thailand. Of the others, one is an Indian species and one Chinese. The Thai species may be identified by the following key:

KEY TO THE SPECIES OF *Macropisthodon* IN THAILAND

1. Maxillary teeth 20-22, including fangs; eight upper labials normally. Body black; a broad orange band across neck separated from head by a broad black band; belly olive with black cross-bands, or entirely black, *flaviceps*
2. Maxillary teeth 14 to 17; seven or eight supralabials. Body grayish rose or reddish brown with a dark brown or black vertebral stripe which becomes a broad V-shaped patch on neck; sides of venter pink, middle part yellow with very small black punctations in a broken row along outer edge of ventrals ..... *rhodomelas*

Macropisthodon rhodomelas (Boie)

(Fig. 59)

Tropidonotus rhodomelas Boie, Isis, 1827, p. 535 (type-locality, Java).

Macropisthodon rhodomelas: Boulenger, Catalogue of the snakes in the British Museum (Natural History), 2nd Ed., vol. 1, 1893, pp. 266-267; Flower, Proc. Zool. Soc. London, 1896, pp. 880-881; *ibid.*, 1899, p. 664; Ridley, Journ. Straits Branch Roy. Asiat. Soc., 1899, p. 198; Boulenger, A vertebrate fauna of the Malay Peninsula . . . 1912, pp. 129-130; Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 160; Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 265; Sworder, Singapore Nat. no. 2, 1922, p. 63; Smith, Bull. Raffles Mus., no. 3, 1930, p. 45; Tweedie, The snakes of Malaya, 1954, pp. 73-74.

Diagnosis: Maxillary teeth, 14-17 followed by two large fangs; nostril between two nasals that are completely or almost completely separated; one loreal, one preocular, three anterior temporals; a black median line expanding anteriorly into a broad V-shaped dark blue or blackish mark.

Description of species (from No. 115, Royal Forest Department Coll., from Khao Chong, Trang): Rostral one third wider than high, very narrowly visible above; internasals shorter and narrower than prefrontals; prefrontals broader than long, forming a

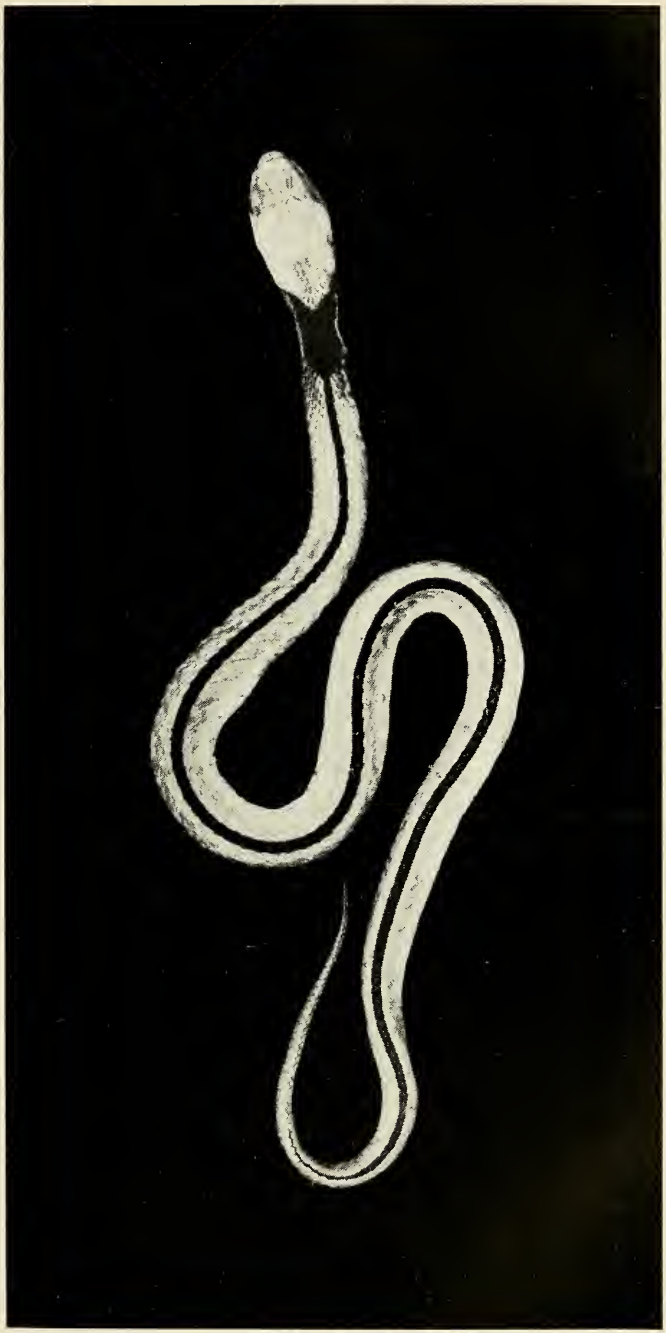

FIG. 59. *Macropisthodon rhodomelas* (Boie). Royal Forest Department No. 115, Khao Chong, Trang province. Actual total length, 286 mm.; tail, 62 mm.

straight suture with frontal; latter slightly longer than its distance to tip of snout, slightly less than its distance from back level of parietals; nasal divided; a loreal as high as long; a single preocular not reaching top of head or frontal; three postoculars, two lower ones elongated; temporals, three anterior, three posterior, with an extra scale intercalated on one side; supralabials, 8-8, fourth and fifth bordering orbit; diameter of eye greater than its distance from nostril; mental triangular; infralabials, 10-10, five touching first chinshields, which are as broad, but considerably shorter than second pair; first pair widened; first ventral directly in contact with second pair of chinshields.

Scale-formula: 29, 23, 19, 19; "apical pits" evident in shed scales as two transparent spots somewhat back from apex, scarcely discernible otherwise; scales keeled except on two (or one) outer rows and on sides of neck. Ventrals, 134; anal, divided, subcaudals, 47, divided, except terminal one. Maxillary teeth, 14-17, last two strongly enlarged and directed backwards.

Color: Top of head, except posterior part of parietals and in supraorbital areas, olive yellow; posterior parts of occiput and temporal regions lavender; nape of neck rosy with two faint darker lines evident, extending from a broad V-shaped nuchal mark to occiput; from posterior part of nuchal mark emerges a discrete black line, covering median scalerow and slightly more than half of adjoining rows, extending to tip of tail; sides of neck rather gray-blue; a small black line along edges of three ventrals; sides rosy pink with fine diagonal darker lines indicated, extending down and forward on sides, each separated by two transverse diagonal rows of scales; a broken, very incomplete line of punctate black marks on outer edge of ventrals; side of venter slightly rosy pink, middle chiefly yellow; tail whitish below, the pink less intense above and disappearing distally.

Measurements in mm.: Snout to vent, 286; tail, 62; width of head, 10.2; length of head, 18.

Variation: A specimen which I captured at Khao Chong had the following coloration in life: Top of head, dark brown, the labials lighter pinkish brown; occiput a lighter brown than top of head; sides with alternate diagonal lines of rusty pink one scalerow wide, separated by two rows of yellowish-brown scales; a black median line from base of tail to neck where it widens into a broad chevron-shaped spot of coal-black, the lateral tips reaching the jaw-angles; scales on neck, along this black spot, bluish gray; entire underside

of head and body flesh pink growing cream near the base of the tail and on subcaudal area; infralabials and chinshields ivory white.

The variation reported for the ventrals is 124 to 138; for subcaudals, 42 to 58. The usual number of labials is seven in which case the third and fourth labials border the orbit; four postoculars may occur.

Distribution: Known in the southern part of peninsular Thailand, having been taken in Trang.

Specimens are known also from Malaya, Singapore, Borneo, and Java.

Remarks: This species has the habit of dilating the neck and behaving somewhat in the manner of the cobra.

Macropisthodon flaviceps (Duméril and Bibron)

Amphiesma flaviceps Duméril, Bibron and Duméril, Erpétologie générale . . . vol. 7, 1854, p. 738 (type-locality, Borneo); Jan, Arch. Anat. Fis., vol. 3, 1865, p. 235; Jan and Sordelli, Iconographie générale, livr. 29, 1868, pl. 3, fig. 1.

Tropidonotus leucomelas Günther, The reptiles of British India, 1864, p. 271, pl. 22, fig. 1 (type-locality, "Pinang"); Müller, Verh. nat. Ges. Basel, vol. 7, 1882, p. 148.

Tropidonotus flaviceps: Günther, Proc. Zool. Soc. London, 1872, p. 590; Fischer, Arch. für Nat., 1885, p. 53.

Macropisthodon flaviceps: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 266; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 128-129; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 266 (Kuala Tahan, Malaya); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 45 (Bandon, most northern record); Tweedie, The snakes of Malaya, 1954, p. 74.

Diagnosis: Maxillary teeth, 18-20 + 2 enlarged fangs; eight upper labials (rarely seven); posterior chinshields longest; one preocular; scales keeled, in 19 rows at middle. Body black with grayish white or pale olive cross-bars, widening towards sides; a broad orange band across neck separated from head by a black band; venter olive with black cross-bands or entirely black.

Description of species: Maxillary teeth 18-20 + 2 enlarged fangs. Rostral twice as broad as deep; internasals shorter than prefrontals; frontal a little longer than broad, as long as or a little shorter than its distance from end of snout, shorter than parietals; loreal as long as deep or deeper; one preocular; three or four (rarely two or five) postoculars; temporals, 2 + 2 or 2 + 3; eight (rarely seven) upper labials, fourth and fifth (or third and fourth) entering eye; five or six lower labials in contact with anterior chinshields; posterior chinshields longer than anterior.

Scales very strongly keeled in 19 rows. Ventrals, 120-138; anal, divided; subcaudals, 49-60.

Color: Body black; young with greyish-white or pale olive cross-bars, widening towards sides and of which at least traces persist in the adult; a broad orange band across nape, sometimes disappearing in adult, separated from head, which is yellowish brown or olive, by a broad black band; venter olive, with black cross-bands, or entirely black (from Boulenger 1912).

Measurements in mm.: Total length, 840; tail, 190.

Distribution: In Thailand the species has been taken at Bandon, Surat Thani province. This is the only record as well as the most northern record. The species is known in the Malay Peninsula south of Thailand, where it is common, and it is present also in Sumatra and Borneo.

Genus *Rhabdophis* Fitzinger

Rhabdophis Fitzinger, Systema reptilium, 1843, p. 27, type of genus *Natrix subminiata* (Schlegel).

Diagnosis: A group of semiaquatic snakes having 22-35 maxillary teeth, last two teeth enlarged into ungrooved fangs, directed backwards; some species with nuchal glands and a more or less distinct nuchal groove (*subminiatus, nigrocinctus*); lacking in other Thai forms; eye rather large, pupil round; scales in 19 keeled rows; subcaudals paired, anal divided.

Four species of this genus are known in Thailand; three of them seem to be lowland in habitat, ascending low hills and the lower parts of mountains; *stolatus* on the other hand is reported as ascending to about 2000 m. It likewise occurs in lowlands in Thailand.

It is difficult to explain the absence of the nuchal glands in *stolatus* and *chrysargus* since the presence of these organs might be regarded as a generic character.

The following key will differentiate the four species:

KEY TO SPECIES OF *Rhabdophis* IN THAILAND

1. Glands present in nuchal region 2
   Nuchal glands absent 3
2. Maxillary teeth, 24-26; one preocular; normally eight supralabials, third, fourth, and fifth bordering eye. Olive brown or greenish, uniform or reticulated; head dark, blackish color extended on neck, followed by reddish or vermillion area for a short distance. Belly yellowish, ventrals often with black outer dots ..... *subminiatus*
   Maxillary teeth 27-29. One or two preoculars; nine (rarely eight) supralabials, fourth, fifth, and sixth labials bordering eye; olive green with vertical black bars on sides or narrow cross-bars (rarely absent or dim); lips white with two black oblique stripes ..... *nigrocinctus*

3. Two light stripes on back; internasals much narrowed anteriorly; venter white with occasional black dots on anterior fourth of body; 21-24 maxillary teeth. . . . . *stolatus*

No light stripes, internasals but little narrowed anteriorly; a white chevron on neck pointing backward; ventrals usually with black spots and a rather heavy peppering of gray pigment; 27-35 maxillary teeth. . . . . *chrysargus*

Rhabdophis subminiatus (Schlegel)

(Fig. 60)

Tropidonotus subminiatus Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 313 (type-locality, Java).

This species, with a very wide distribution extending from Java to Sikkim and Kwangsi (in China), shows considerable variation. Several subspecific forms have been described, some of which are good, some questionable. In Thailand two forms have been recognized—the typical *subminiatus subminiatus* and a northwestern, high-altitude form—*subminiatus helleri* Schmidt. The two may be separated as follows:

KEY TO THE FORMS OF *Rhabdophis subminiatus*

1. A distinct oblique black bar below eye; center yellowish sometimes with a black dot on outer end of each ventral shield. Neck with a vermillion band, the color largely on skin between scales. Ventrals, 137-164, subcaudals, 72-89. Nuchal glands and groove not conspicuous (may be absent in the south *fide* M. Smith); length to 750 mm., *R. subminiatus subminiatus*

2. Adults almost uniformly colored; *venter powdered gray;* the subocular bar present, absent, or indistinct; paired glands and a groove present on neck, usually distinct. Ventrals, 157-173, subcaudals, 72-96, length to 1300+ mm. . . . . *subminiatus helleri*

Rhabdophis subminiatus subminiatus (Schlegel)

Tropidonotus subminiatus Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 313 (type-locality Java); Günther, The reptiles of British India, 1864, p. 265; Flower, Proc. Zool. Soc. London, 1899, p. 662; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 56, 65; Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 347; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, p. 256; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 126-127; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 320; *ibid.*, vol. 19, 1909, pp. 341, 618; Venning, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910-1911, pp. 341, 773; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, pp. 15, 187, 213, 245, *ibid.*, vol. 2, pt. 2, 1916, p. 158 (Narathiwat and Nakhon Si Thammarat).

Rhabdophis subminiatus: Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 606; *ibid.*, vol. 30, 1925, p. 810; *ibid.*, vol. 31, 1926, p. 561; Bourret, Les serpents de l'Indochine, 1936, p. 95.

Natrix subminiata: Sworder, Singapore Nat., no. 3, 1924, p. 21; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 44; Proc. Zool. Soc., 1938, p. 579; Tweedie, The snakes of Malaya, 1954, pp. 69-70, text fig. 16b.

Natrix subminiatus subminiatus: M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 302-303, fig. 95, ch. (teeth).

?*Natrix subminiata hongkongensis* Mell, Lingnan Sci. Journ., vol. 8, 1931, p. 203 (type-locality, Hong Kong).

?*Natrix subminiata siamensis* Mell, Lingnan Science Journ., vol. 8, 1931, p. 203 (type-locality, Siam); Gressit, Peking Nat. Hist. Bull., vol. 15, 1941, p. 187.

Rhabdophis subminiatus helleri: Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1152-1153 (*part.*).

NOTE: It is not certain that all the references here included actually belong to the typical form.

Diganosis: A medium-sized form with a series of nuchal glands; nuchal scales not enlarged, nuchal groove may be indistinct. Maxillary teeth, 24-26, last two abruptly and strongly enlarged; internasals as long as prefrontals in southern—, shorter in northern specimens; one preocular; scales in 19 rows at middle. Neck vermillion, following an olive-green nuchal band.

Description of species (from No. 24 ♂ Bangkok, Thailand): Rostral about one-fourth to one-third wider than high, narrowly visible above; internasals distinctly shorter than prefrontals, narrowed to half their width anteriorly; prefrontals at least one-third wider than long; laterally forming sutures with three scales, that with loreal shortest; frontal length approximately equal to its distance from end of snout, shorter than parietals; nasal divided, posterior portion highest, forming an angle above; loreal about as high as long; preocular barely reaching upper surface of head; three postoculars; temporals, 2 + 3, lower anterior smallest; eight supralabials, third, fourth, and fifth entering obit; sixth and seventh subequal or seventh largest; length of eye equal to its distance from front edge of nostril; nine infralabials, four or five touching first chinshields which are considerably shorter than second pair; latter scales separated by small scales.

Scale-formula: 24 (occiput); 21, 19, 17, outer row smooth, others strongly keeled, most scales bidentate posteriorly; ventrals, 169; subcaudals, 62; anal, divided.

Color in life: Head olive becoming olive-green on neck, bordered behind by a somewhat lighter edge coming to a point posteriorly on nape; neck more or less vermillion to rusty red with dark spots arranged quincuncially, gradually becoming grayish olive; skin on body alternately blackish and yellowish, the color sometimes encroaching on edges of adjoining scales thus producing a very indefinite pattern until skin of body is stretched, separating scales, when this pattern becomes strongly evident; towards posterior part of body the pattern becomes indefinite; labials cream with a prominent black diagonal line below eye, directed downwards and backwards. Ventrals grayish olive on outer ends; mesial portion

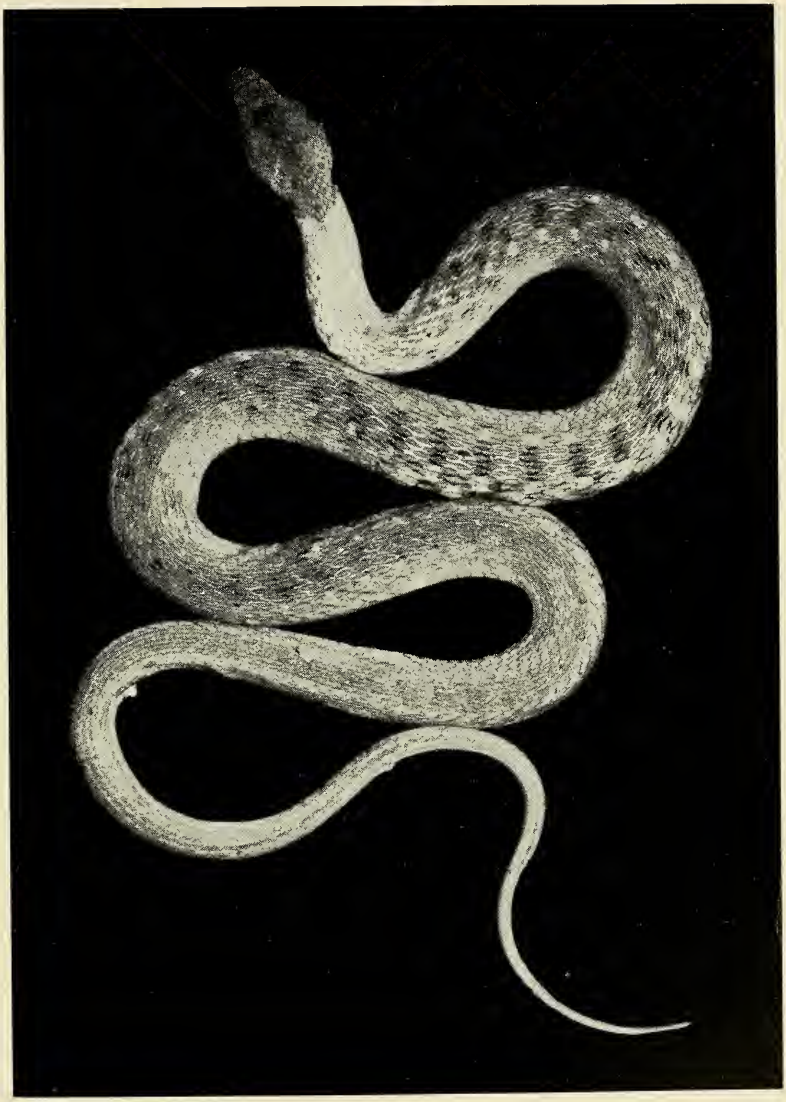

FIG. 60. *Rhabdophis subminiatus subminiatus* (Schlegel). No. 3337 ♂, Bangkok (city), Thailand. Actual total length, 628 mm.; tail, 178 mm.

of venter yellowish on throat and neck, becoming grayish to ivory posteriorly.

Measurements in mm.: Snout to vent 630; tail (part missing), 160.

Variation: The known range in ventrals is from 137 to 164; in the subcaudals from 72 to 89. The lower ventral and higher sub-

caudal counts are those found in males. The species reaches a known length of a little less than 800 mm., growing perhaps a little larger in the northern part of its range. The number of maxillary teeth in specimens from Ronpibon, Nakhon Si Thammarat is 20 (21) + 2 in three specimens, while one has 23 (21) + 2. There may be nine supralabials.

Distribution: The species occurs in northern Thailand to about latitude 22° N, and extends to southern Thailand. Specimens are known from Chiang Mai, Bangkok, Nakhon Si Thammarat and Narathiwat. Outside of Thailand it occurs in Indo-China and Malaya.

Remarks: The specimen figured was apprehended in the kitchen of a dwelling house in the city of Bangkok by Mrs. Kenneth Dilks, Lecturer, Chulalongkorn University, who kindly presented the specimen to the University collection.

When the snake is excited it often elevates its head and flattens and distends the body thus displaying the hidden pattern between the scales.

Rhabdophis subminiata helleri K. Schmidt

Natrix helleri Schmidt, Amer. Mus. Novitates, no. 157, 1925, p. 3 (type-locality, Tengyueh 5500 ft. altitude, Yunnan, China. Dr. M. Smith (1943) gives Nodoa, Hainan as the type-locality, which is the type-locality of another species of *Natrix* also described on the same page by Schmidt. This is presumably a clerical error unless it represents a correction of the previously stated type-locality).

Tropidonotus subminatus: Anderson, Zool. Res. West Yunnan, 1879, p. 822.

Natrix subminiata helleri: Pope, The reptiles of China, 1935, pp. 132-135, fig. 30; M. Smith, Rec. Indian Mus., vol. 37, 1935, p. 239; *ibid.*, vol. 42, 1940, p. 483; The fauna of British India, Ceylon and Burma including the whole Indo-Chinese Subregion; Reptilia and Amphibia, vol. III, Serpentes, Dec. 1943, pp. 302-303; Fan. Bull. Dept. Biol. Col. Sci. Sun Yat Sen Univ., no. 11, p. 60 (Kwangsi); Mell, Lingnan Sci. Journ., vol. 8, p. 203.

Diagnosis: See key.

Description of subspecies (from Schmidt in Pope, *loc. cit.*, pp. 133-134). Nineteen subequal maxillary teeth, followed by two strongly enlarged ones. Rostral visible from above; internasals as long as broad, their sutures with the rostral subequal to those of rostral and first labial; internasals slightly shorter than the prefrontals; frontal slightly longer than its distance from the rostral, slightly shorter than the parietal suture; parietals truncate behind; frontal wider than the supraoculars; nasal divided; loreal higher than long; eight upper labials, sixth largest, seventh highest, the

third, fourth and fifth entering the eye; ten infralabials; a single preocular; postoculars, 2 or 3; temporals, 2 + 2. Dorsal scales in 19 rows at mid-body, 22 on neck, and 17 near tail, narrow, strongly keeled, and notched at tip; outer scalerow smooth; a pair of faint apical pits often difficult to discern; ventrals, 169; tail, incomplete.

Color: General color uniform olive, with reddish markings on the neck, chiefly confined to the skin between the scales; infralabials cream; supralabials gray anteriorly and posteriorly, the middle one lighter, with a black mark on the suture between the fifth and sixth. Ventrals grayish.

Measurements in mm.: Total length, 860; tail 197.8.

Variation: The largest specimen recorded by M. Smith is a female whose total length was 1300 mm., the tail 300 mm. The range of ventrals for the species is from 160 to 180, the subcaudals, 73 to 92.

Remarks: Two specimens of this form No. 25 and 36543 are at hand, the former from an uncertain locality (ventrals 158, subcaudals, 68), the latter from northern Chiang Mai province. Besides the heavy gray dorsal coloration on the outer edge of ventrals a considerable number also have a discrete black spot in this area. The chin is ivory in preservation and all the ventrals have considerable gray pigment on their anterior parts.

Rhabdophis nigrocinctus (Blyth)

(Fig. 61)

Tropidonotus nigrocinctus Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1856, p. 717 (type-locality, Pegu, Burma); Theobald, Journ. Linnaean Soc., vol. 10, zoology, May 30, 1868, p. 48 (Pegu); Boulenger, Fauna British India . . . Reptilia and Batrachia, 1890, p. 346; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, pp. 255-256; Smith and Kloss, Journ. Nat. Hist. Siam, vol. 1, pt. 3, 1915, p. 244; Smith, *ibid.*, 1916, vol. 2, p. 159.

Rhabdophis nigrocinctus: Wall, Journ. Bombay, Nat. Hist. Soc., vol. 19, 1923, p. 606; Bourret, Les sepents de l'Indochine, 1936, p. 91.

Natrix nigrocinctus: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, 1922, p. 206-207; Proc. Zool. Soc. London, ser. B. 1938, p. 579; Bull. Raffles Mus., no. 3, Apr. 1930, p. 44 (Tasan, Tapli, Chumphon); The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 307-308.

Tropidonotus eisenhoferi Gyldenstolpe, Kungl. Sv. Vet. Akad. Hand., Stockholm, Band 3, 55, p. 11, text fig., (type-locality, Muang Fang, N. Siam).

Pseudoxenodon fruhstorferi Werner, Sitz. Ber. Akad. Wiss. Wien, vol. 134, 1925, p. 49 (type-locality, Siam); M. Smith Ann. Mag. Nat. Hist., series 10, vol. 1, 1928, p. 496 (= *nigrocinctus*).

Diagnosis: Scales in 19 rows, with bidentate tips, all keeled. One or two preoculars; nine supralabials; more than 25 maxillary teeth,

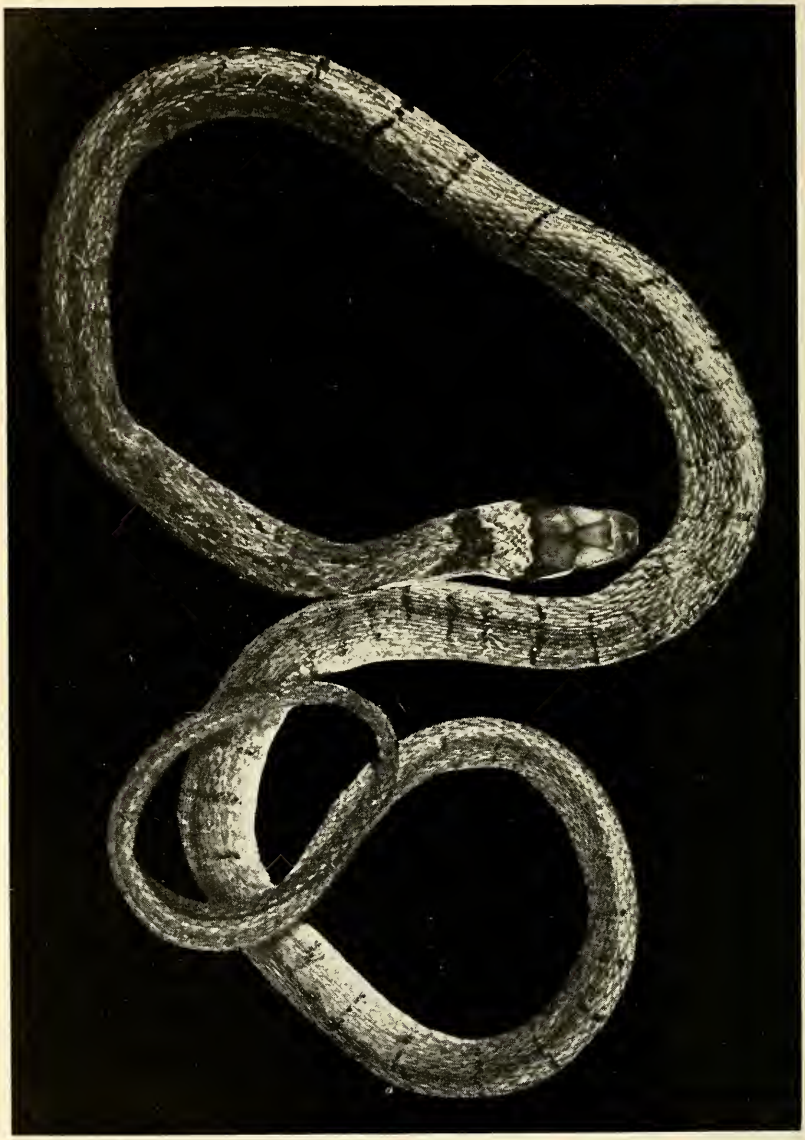

FIG. 61. *Rhabdophis nigrocinctus* (Blyth). No. 21, Doi Suthep, Chiang Mai province. Actual total length, 596 mm.; tail, 159 mm.

last two teeth abruptly much enlarged; internasals broadly truncate anteriorly; nostrils lateral. A nuchal groove and glands present;* one anterior temporal.

Description of species (from No. 21, Doi Suthep, Chiang Mai):

* In his Key, Smith (p. 248 [1943]), inadvertently places *nigrocinctus* in the section B. "without nuchal glands." On p. 15 he correctly states that the glands are present.

Head distinct from neck. Rostral about twice as wide as high; internasals broadly truncate anteriorly, suture between them slightly shorter than that between prefrontals; latter scales broader than long; frontal five-sided, its length greater than its distance to tip of snout, slightly shorter than parietal; nasal divided, posterior part higher than anterior; loreal longer than high; one preocular, reaching top of skull but separated from frontal; four postoculars; two anterior temporals (the upper divided), three posterior; supralabials, 9-9, fourth, fifth, and sixth enter orbit, seventh and eighth largest; infralabials, 10-10, five touching first chinshields which are somewhat wider but scarcely as long as second pair; latter separated by a scale.

Scale-formula: 22 (occiput), 19, 19, 17, all strongly keeled including outer row. Ventrals, 159; anal, divided; subcaudals, 88.

Five pairs of rounded nuchal glands. Externally there is no distinct groove evident to suggest their presence. Maxillary teeth 28, last eight or ten a little larger than others and after a short diastema followed by two enlarged fangs, without grooves, directed posteriorly.

Color in life: Above olive-green; posterior part of body with a brownish wash. A series of black bars on each side often joining on middle of back. Chin and throat cream-white gradually becoming gray on venter; back part of each ventral whitish without pigment; subcaudals grayish black outlined in white; head blackish brown; supraoculars gray; grayish loreal region; lower edges of anterior labials and whole of posterior labials cream, save for a diagonal black line from eye to mouth, and a larger black spot from parietal to angle of mouth; a light gray band (white in young) crosses occiput behind parietals and angle of mouth; this followed by a deep black chevron-shaped spot.

Measurements in mm.: Total length, 596; tail, 159; width of head, 11.3; length of head, 19.

Variation: Malcolm Smith states that the outer row of scales is usually smooth. The know range of ventrals is from 150 to 170; of subcaudals, 80 to 97.

M. Smith shows that there is some geographical variation in the count of scales on venter and subcaudal regions as follows:

1. Northern Thailand and Pegu—One preocular; ventrals 161-170; subcaudals, 83-96. Adults with distinct cross-bars.

2. Peninsular Thailand—One preocular; ventrals, 150-157; subcaudals, 72-82 marked with distinct black cross-bars.

3. Southeastern Thailand—Two preoculars, ventrals, 156-164; subcaudals 74-84 cross-bars indistinct or absent.

Remarks: This snake is semiaquatic, feeding on frogs and fish.

Distribution: Widespread in Thailand. It has been taken in Chiang Mai, Chumphon, and Chanthaburi. It is also known in Burma, and Indochina. It has not, to my knowledge, been taken in Malaya.

Rhabdophis stolatus (Linnaeus)

(Figs 62, 63)

Coluber stolatus Linnaeus, Systema naturae, 10th Ed., 1758, p. 219; *ibid.*, 12th Ed., 1766, p. 399 (type-locality, "America" = Asia); Anderson, Bih. Sven. Vet. Akad. Handl. Stockholm, vol. 24, (4), 6, 1899, p. 12.

Tropidonotus stolatus: Boie, Isis, 1827, p. 535; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 937; Günther, The reptiles of British India, 1864, p. 266; Theobald, Journ. Linn. Soc., vol. 10, Zoology, no. 41, 1868, p. 47. ("Seasonally head neck and sides are deeply suffused with vermillion").

Tropidonotus stolatus: Tirant, Notes sur les reptiles et batraciens de la Cochinchine et du Cambodge, 1885, p. 56; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 348-349, fig. 101; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, 1893, pp. 253-254; Wall, Journ. Bombay Nat. Hist. Soc., vol. 16, 1905, p. 302; *ibid.*, vol. 18, 1907-08, pp. 108, 205, 320; *ibid.*, vol. 19, 1909, p. 615; *ibid.*, vol. 20, 1911, p. 603 pl. *ibid.*, 26, 1919, p. 562; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 125-126, fig. 43.

Rhabdophis stolatus: Wall, The snakes of Ceylon, 1921, p. 105; Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 605; Prater, *ibid.*, vol. 30, 1924, p. 168; Fraser, *ibid.*, vol. 39, 1937, p. 469; Bourret, Les serpents de l'Indo-Chine, 1936, p. 92; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1153-1154, fig. 30 (Ban Na Phua, Kan Luang, Nakon Phanom).

Natrix stolata: Pope, The reptiles of China . . . in Natural history of central Asia, vol. 10, 1935, pp. 128-131; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, pt. 2, p. 24; Shaw, Shebbeare and Barker, Journ. Darjeeling Nat. Hist. Soc., vol. 13, 1939, p. 121; M. Smith, Fauna of British India . . . vol. 3, Serpentes, 1943, pp. 303-305.

Tropidonotus ruficeps Peters, Monatsb. Akad. Wiss. Berlin, 1869, p. 44 (type-locality, "California").

Diagnosis: A natricine snake lacking glands on neck. Last two or three maxillary teeth abruptly enlarged into ungrooved fangs, directed somewhat backwards; internasals narrowed anteriorly; nostrils lateral; scales in 19 rows; two light stripes on back; venter white.

Description of species (From No. 1 ♀, Doi Suthep, Chiang Mai): Rostral about twice as wide as high, well visible above; internasals subtriangular, narrowed anteriorly, less than half size of prefrontals; latter much wider than long, forming their shortest lateral suture with frontal; frontal slender, scarcely wider than supraocular, con-

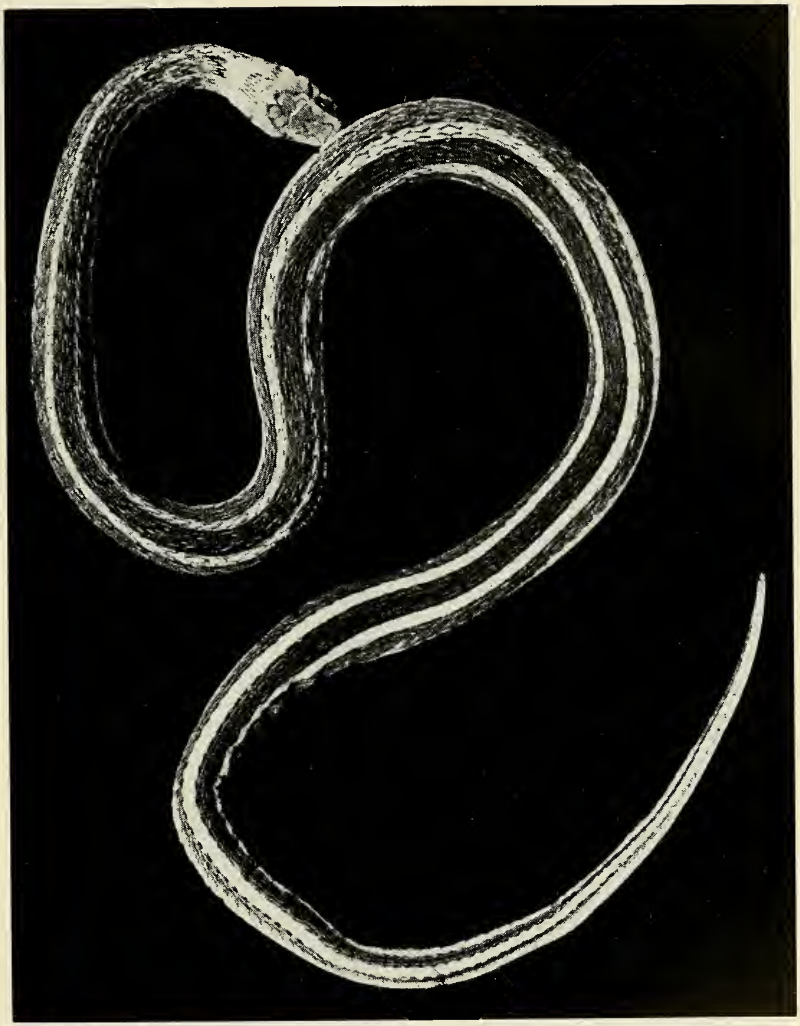

FIG. 62. *Rhabdophis stolata* (Linnaeus), EHT-HMS No. 31761, Ban Na Phua, Na Kae, Nakhon Phanom (province), Thailand. Actual total length, 448 mm. (From Taylor and Elbel.)

siderably longer than its distance from end of snout, approximately as long as parietal; nasal divided, posterior part the larger; loreal a little higher than long; a large preocular reaching top of head, rather narrowly separated from frontal; three postoculars, the temporal touching two lower (or only middle one); temporals, $1 + \frac{2}{1}$; supra-

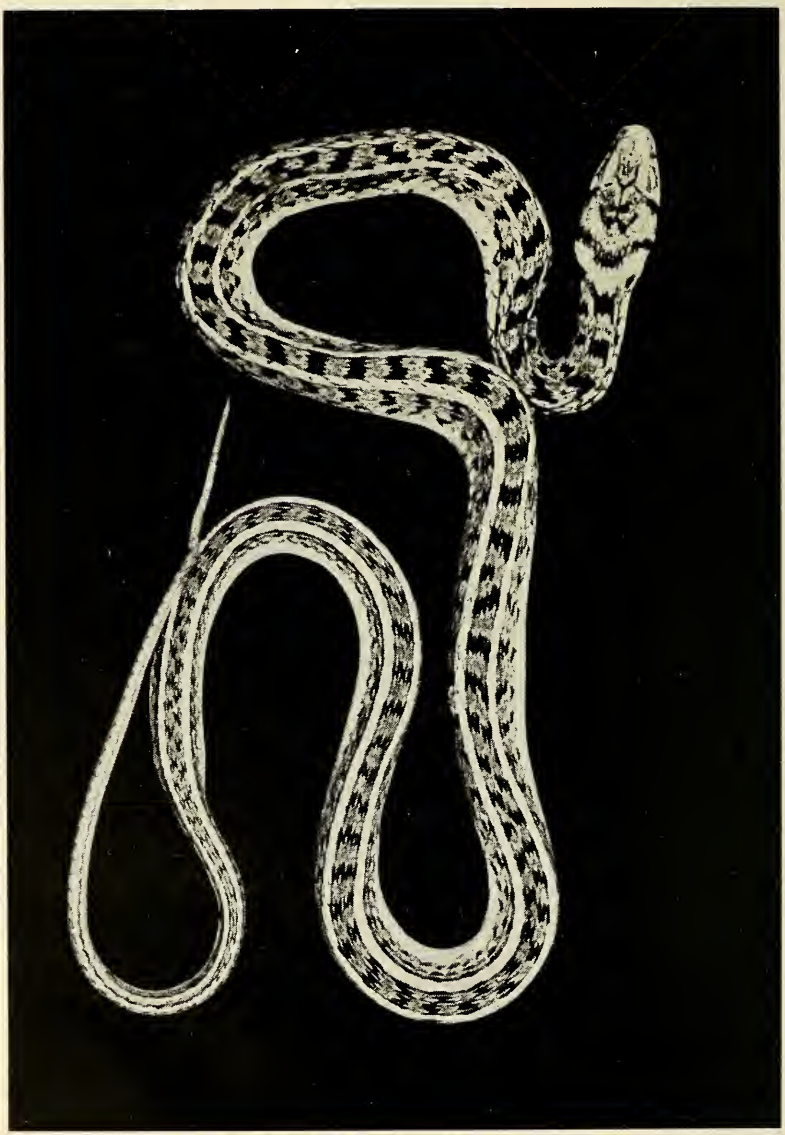

FIG. 63. *Rhabdophis stolatus* (Linnaeus). No. 33179 ♀, near Sara Buri, Sara Buri province. Actual total length, 524 mm.; tail, 131 mm.

labials eight, third, fourth, and fifth entering orbit; seventh largest; infralabials, 10-10, first five bordering first pair of chinshields which are much shorter than posterior; latter separated by small scales.

Scale-formula: 24 (occiput), 19, 19, 17, keeled, except those of outer enlarged row; ventrals, 147½; anal, 2; subcaudals, 35 + (tip of tail missing).

Color in life: Head brownish olive above; supralabials whitish becoming gray posteriorly, sutures blackish as well as upper edge of those labials below eye; two wider black diagonal lines from eye on fifth and sixth labials; spots also on last two labials; light marks on preocular and postoculars bordered by black; chin, infralabials and throat white; body grayish brown with two light dorsolateral stripes, at first not continuous but with small white flecks separated by gray-white; this occupies sixth row and half of two adjoining rows; stripes wider posteriorly only because scales are larger; venter somewhat bluish white; ends of ventrals with some grayish pigment and occasional black spots especially on anterior fourth of body; lower half of outer scalerow whiter than venter forming a ventrolateral stripe; a gray-brown stripe between light stripes on back; those on sides have black spots, distinct anteriorly but posteriorly they are obscured and scarcely distinguishable from ground-color.

Measurements in mm.: Snout to vent, 362; tail, 66 (incomplete); width of head, 11.5; length of head, 18.

Variation: No. 36131 ♂ (from the same locality as the described) specimen yields the following data: head scales identical to described specimen; scalerows reduce to 15 in front of vent; ventrals, 146; subcaudals, 76. This specimen is much lighter on body and the head is also much lighter; snout grayish amber; middle of head across supraorbital region grayish with dark marks on frontal; parietals with some irregular blotches; temporal region and occiput fawn; a black chevron on back of occiput directed backwards, followed by a broader light chevron. The line from eye across first temporal and sixth labial, prominent; black on scales bordering orbit, but sutures are not black; body colored similarly to the one described. No. 33179 (figured) has spoting more distinct.

The specimen figured by Taylor and Elbel shows markings somewhat similar to that last described save that they are less distinct. The ventrals are 144; the subcaudals are incomplete. Smith (1943) gives the range of ventrals as 118 to 158; subcaudals, 50 to 89. The range of the four Thai specimens is 144 ♀ to 147½ ♂ for ventrals; 75 ♀ to 76 ♂ for subcaudals.

Distribution: This subspecies occurs from China through northern (and perhaps southern) Indochina, Thailand north of the peninsula, Burma, Ceylon, and India. It ascends to nearly 2000 M. in the mountains. My Doi Suthep specimens are however from a point with an elevation of only a few hundred feet.

In Thailand it has been reported from the provinces of Chinat, Lopburi, Chiang Mai, Nakon Phanom, and Nakhon Sawan (Paknampho).

Rhabdophis chrysargus (Schlegel)

(Fig. 64)

Tropidonotus chrysargus Boie, Isis, 1827, p. 534 (type-locality, Java) *nomen nudum;* Schlegel, Essai sur la physionomie des sepents, vol. 2, 1837, p. 312, pl. 12, figs. 6, 7; Boulenger, The fauna of British India, Ceylon and Burma Reptilia and Batrachia, 1890, pp. 345-346 (*part.*); Catalogue of the snakes in the British Museum, 2nd Ed., vol. 1, pp. 258-269; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 127-128; Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 161; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914-1915, pp. 130, 155, 213; Smith and Kloss, *ibid.*, vol. 1, no. 4, Dec. 1915, p. 244 (Klong Menao, Trad).

Natrix chrysarga: M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 308-309; Journ. Federated Malay States Mus., 1922, p. 265; Bull. Raffles Mus., no. 3, 1930, p. 44; Tweedie, The snakes of Malaya, 1954, pp. 65-66; figs. 15 a, b.

Rhabdophis chrysargus: Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1923, p. 606 (*part.*); Angel, Bull. Mus. Nat. Hist. Paris, ser. 2, vol. 1, 1929, p. 76.

Tropidonotus junceus: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, pt. 2, pp. 93 (reprint?); Girard, U. S. Exploring Expedition . . . 1858, p. 145, pl. 13, fig. 1.

Tropidonotus chrysargus: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2 (*part.*) Dec. 1916, Maprit, Klong Bang Lai, Prachuap Khiri Khan; Khao Wang Hip, Nakhon Si Thammarat).

Diagnosis: A relatively small water snake (total length to 715 mm.). Maxillary teeth, 27-35, curved backwards rather strongly, the last two strongly and abrupted enlarged; nine supralabials; temporals, 2 + 2. Scales in 19 rows, all keeled except anterior part of outer scalerow; relatively low number of ventrals, (155-165); subcaudals, 80 to 101. A whitish color edged with black; labials cream or yellow with black sutures and a cream line running up from mouth angle; dorsolateral series of lighter spots (whitish or pinkish) with small blackish spots on each side; the black color may form a line across dorsum. Light spots absent on anterior fifth of body; outer part of ventrals with double rows of small black spots and a median ventral row also present.

Description of species (from No. 35874 ♀): Rostral about one and one-third times as wide as high, narrowly visible above; internasals narrowed but little anteriorly, as long as prefrontals; latter wider than long, slightly notched on their anterior faces by the

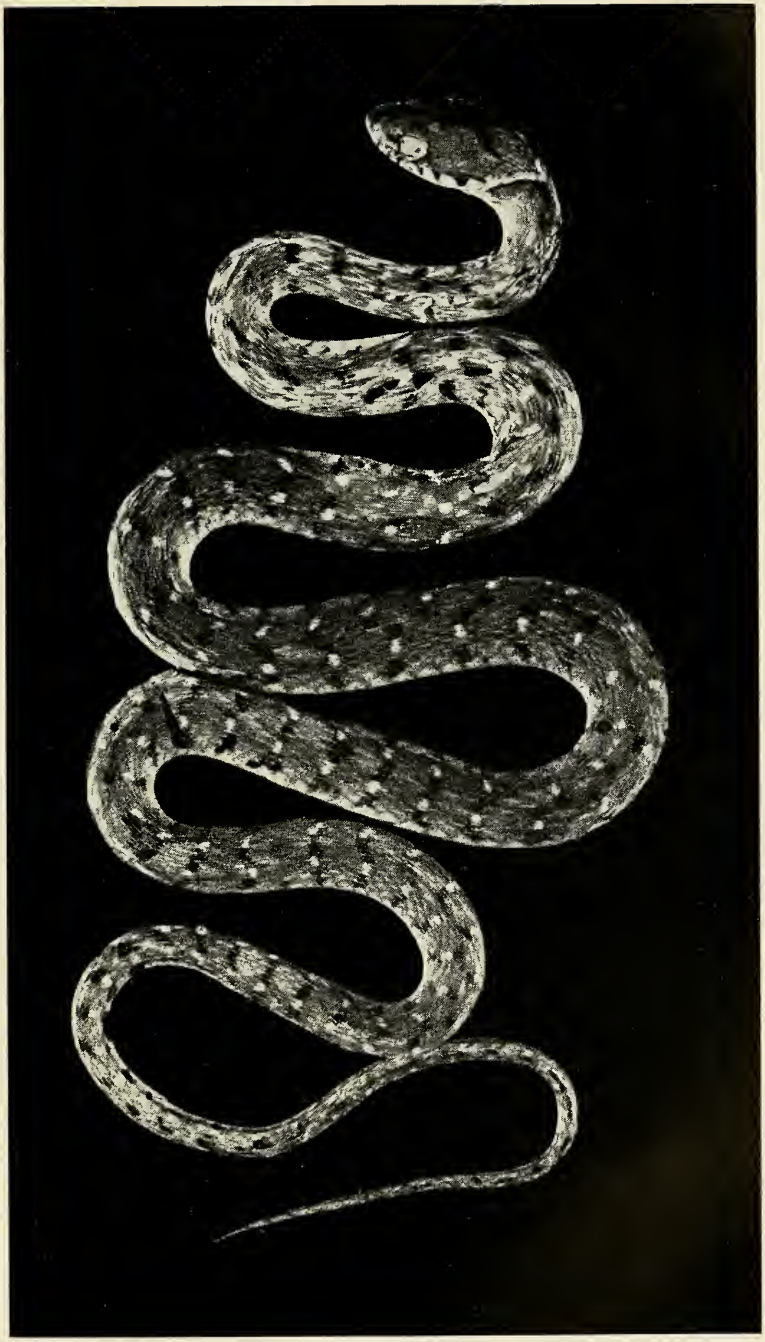

FIG. 64. *Rhabdophis chrysargus* (Schlegel). No. 35874 ♀, Forest Experimental Station, Khao Chong, Trang province, southern Thailand. Actual total length, 637 mm.; tail, 160 mm.

internasals; frontal wider than supraoculars, about one and one-fourth times as long as wide, a fourth longer than its distance from end of snout, a little shorter than parietals; nasal more or less completely divided, anterior part a little the larger; loreal a little longer than high; one preocular reaching upper surface of head; three postoculars; temporals, 2 + 1 + 2, (2 + 3); supralabials, 9-9, fourth, fifth, and sixth border orbit, eighth largest; infralabials, 10-10, first five border first chinshields which are shorter than second pair; latter separated by scales; eye large, as long as its distance from rostral.

Scale formula: 24 (occiput), 19, 19, 17, scales keeled except anterior part of outer row. Ventrals, 153; subcaudals, 80; two anals. Maxillary teeth 28, last two on each side enlarged.

Color: Head blackish olive, as is occiput and nape; supralabials cream, the sutures black; white lines from angles of mouth run backwards and upwards to form a white chevron pointing backwards, bisecting the black area on nape; behind black area anterior fifth of body brownish, skin between scales pinkish; a series of small black spots forming an incomplete reticulum, the spots across middle largest; a series of light spots on each side of latter four fifths of body that are more or less surrounded by darker color and often connected by a narrow black line or band across middle of back; tail similarly but indistinctly marked. Chin and throat white, neck and first fifth of venter pinkish ivory with dots on outer ends of ventrals; beginning in second fifth the outer edges of ventrals dark gray, with a black dot usually present; a median line of dark dots continues to vent; other fine pigment scattered posteriorly; subcaudal region with two rows of dark spots and much scattered pigment.

Measurements in mm.: Total length, 637; tail, 160; width of head, 11.5; length of head, 19.5.

Variation: The details of coloration vary somewhat with age. The white chevron on the nape may disappear in older specimens; and the blackish color on head and neck may likewise tend to disappear. No. 3479, Na Pradoo lacks the chevron.

Variation in the ventral count is from 153 to 165; in the subcaudals, 80 to 101.

Distribution: In Thailand the species occurs from the southern peninsular border to Chiang Mai in the north. Outside of Thailand the species is known in Cambodia and Tenasserim, Malaya and the larger East Indian Islands.

Remarks: The described specimen is from Khao Chong, Trang.

Subfamily BOIGINAE

KEY TO GENERA * SUBFAMILY BOIGINAE

1. Median maxillary teeth not larger than the remainder of series preceding the posterior fangs 2
   Median maxillary teeth (3rd and 4th or 4th and 5th) distinctly enlarged, usually followed by a diastema 3
2. Maxillary teeth ten to fourteen, subequal in size followed after a short diastema by two much-enlarged grooved fangs; arboreal serpents, one to two and one-half meters in length ..... *Boiga*
   Maxillary teeth 20-22, last three or four a little larger and grooved; ventrals sharply angulate; slender arboreal snakes reaching a length of little more than one meter ..... *Chrysopelea*
3. Body slender, elongate, compressed; snout terminating in a sharp point or with a pointed dermal projection; maxillary teeth, 12-15, the anterior six or seven rapidly increasing in size followed by a diastema, then eight smaller teeth preceding two enlarged grooved fangs ..... *Dryophis*
   Body not especially slender or elongate, the snout not pointed 4
4. Anal single; pupil vertically elliptic; ten to twelve maxillary teeth, the fourth and fifth strongly enlarged ..... *Psammodynastes*
   Anal divided; pupil round; median maxillary teeth feebly enlarged, *Psammophis*

* Key characters apply at least to Thai species.

Genus *Boiga* Fitzinger

Boiga Fitzinger, Neue Classification, Reptiles, 1826, pp. 29, 31, 60 (type of genus, *Coluber irregularis* Merrem): Cope, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 264.

Eudipsas Fitzinger, Systema reptilium, 1943, p. 27 (type of genus, *dendrophila.*

Dipsas Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 357.

Dipsadomorphus Fitzinger, Systema reptilium, 1843, p. 27 (type of genus *D. drapiezii*); Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 59.

Diagnosis: Maxillary teeth from 9 to 14, followed after a short interval by two or three enlarged grooved fangs; anterior mandibular teeth much enlarged or anterior teeth nearly equal in size to posterior. Head strongly distinct from neck; body strongly compressed; eye large, pupil vertical. Hypapophyses usually developed posteriorly on vertebrae. Scales smooth with apical pits, 17 to 31, scalerows transversely oblique; subcaudals divided; nasal single or at most partially divided, posterior part concave; ventrals angulate laterally.

Of the seven species of *Boiga* known to occur in Thailand only three have a wide distribution in the country. The smallest one, *multomaculata* * reaches as far north as China, and has been taken in Chiang Mai, Loei and Chon Buri provinces and on certain islands in the Gulf of Siam. Strangely enough it has not been taken in southern Thailand, Malaya, or Singapore, but it does occur in Java, Sumatra, and Borneo.

* Spelled so by Boie (1827).

Boiga cynaea, the green cat snake, has a range extending from Darjeeling and Assam south through Burma, Thailand, Cambodia, and the island of Koh Pu-Ngan in the Gulf of Siam. It appears to be unknown in southern Thailand, Malaya and the islands to the south.

Boiga cynodon, which has two forms, usually regarded only as color varieties, covers the western part of Thailand from Loei province south to Trang. It is known in Malaya, Singapore and the Indo-Australian archipelago. Four other species *drapiezii, nigriceps, jaspidea,* and *dendrophila* enter Thailand from the south and it is doubtful that they are to be found north of the Nakhon Si Thammarat mountains. The dark "color variety" of *cynodon* has been taken only in the southern province of Pattani.

Boiga hexagonotus has been reported from Thailand, but this would appear to be the result of some metathesis of data. This nominal species is a synonym of *Boiga achracea,* an Indian species.

KEY TO THAI SPECIES OF *Boiga*

1. Scalerows at middle of body, 19 (rarely 17) 2
   Scalerows 21 or more than 21 at middle of body 3
2. A pair of black stripes on venter; subcaudals 114-169; eye as long as snout. Large species reaching two meters in length ..... *drapiezii*
   No stripes; venter whitish, marbled and spotted with brown, and a series of brown spots along each side; subcaudals, 80-106; small species one meter or less in length ..... *multomaculata*
3. Scalerows 21 4
   Scalerows 23-25 7
4. Uniform green, the interstitial skin black; young greenish or grayish with indefinite darker pattern; subcaudals, 124-138; temporals usually, 2 + 3. Large species, to one-and-three-fourths meters ..... *cyanea*
   Adults not green 5
5. Body deep black with yellow vertical bars on sides of body and tail; snout longer than eye; subcaudals, 89-110 ..... *d. melanota*
   Body not so colored 6
6. Head blackish; body reddish or pale grayish brown uniform or mottled; upper lip and venter yellowish white ..... *nigriceps*
   Head shields with discrete, more or less symmetrical light-edged black spots; a ventrolateral series of white spots, two or three scales in area, partly on ventrals. Body light brown or reddish brown, mottled or speckled with brown or black and with blackish cross-bands interrupted on the median line. Large species (to two meters) ..... *jaspidea*
7. Uniform fawn with black chevron-shaped marks enclosing lighter marks on middorsal line; a series of whitish marks on outer scalerows; head nearly uniform fawn with a well-defined dark black stripe behind eye; anterior mandibular teeth much enlarged. Large snakes (to two meters or more), *cynodon*
   Generally grayish black with darker blackish blotches separated in the adults by dark grayish areas; a dark black stripe behind eye; anterior mandibular teeth enlarged. Large snakes (to two meters) . . . *cynodon* var

These snakes are arboreal for the most part and feed on a variety of foods, such as birds, snakes, mammals, frogs, fish, etc. I have found *multomaculata* in a small shrub tightly coiled about a small branch, and another specimen under a rock near the edge of a small pool. *Dendrophila* is perhaps somewhat aquatic as they are almost invariably found in the vicinity of streams or along coastlines where there are mangrove swamps. They often bask in the trees near the edge of streams and occasionally three or four may be seen in a single tree. If disturbed they may take a dive into the water and swim below the surface until they reach shore, or they may take temporary refuge under some submerged object. They are reputed to eat fish almost exclusively.

Boiga drapiezii (Boie)

Dipsas Drapiezii Boie, Isis, 1827, p. 559 (type-locality, Java); Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 270, pl. 9, figs. 8, 9; Abbildungen . . . 1840, p. 48, pl. 15; Günther, Ann. Mag. Nat. Hist., ser. 3, vol. 9, 1862, p. 53.

Triglyphodon Drapiezii Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, pt. 2, 1854, pp. 1097-1101.

Dipsadomorphus drapiezii Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 74-75; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 171; M. Smith, Bull. Raffles Mus., no. 3, Apr., 1930, p. 64; Sworder(Singapore Nat., no. 2, 1922, p. 66 (Singapore).

Boiga drapiezii Tweedie, Bull. Raffles Mus., no. 23, Dec., 1950, pp. 196-197 (Selangor, Malaya); *ibid.*, no. 25, Dec., 1954, pp. 113-115, fig. 2 (Johore, Perak, Pahang, Selangor, North Natuna Islands).

Diagnosis: A large species reaching a length of more than two meters; a large preocular reaching top of head, often to frontal; 19 scalerows, the vertebral row enlarged; a pair of black lines on venter.

Description of species (from C.U. No. 2622, Na Pradoo, Pattani): Head very distinct from neck; body compressed. Rostral wider than high, barely visible above; internasals broader than long, narrowed to a small angle laterally; prefrontals much wider than long, extending down on sides of head to level of middle of eye, their common suture distinctly longer than that between internasals; frontal longer than wide (5×3.2 mm.), the sides emarginate, its length greater than its distance from tip of snout, shorter than parietals; supraocular as long but not as wide as frontal; nostril in a partially divided nasal, posterior part largest and somewhat concave behind nostril; loreal small, as wide as high; a preocular reaching upper surface of head but narrowly separated

from frontal; two postoculars, upper largest; temporals, $3 + \frac{1}{2+2}$; eye very large, its diameter distinctly greater than length of snout; pupil vertical; eight supralabials, 3rd to 5th bordering orbit; mental about as wide as base of rostral; eleven infralabials, first six border first chinshields which are a little larger than second pair, neither pair separated; scales smooth, with apical pits.

Scale-formula: 25 (occiput), 19, 19, 13; transverse rows diagonal; median dorsal row not strongly widened anteriorly, wider posteriorly. Ventrals, 279; anal, single; subcaudals (divided), 168; ventrals and subcaudals obtusely angulate laterally.

Color: Pale fawn, head nearly unicolor; no dark line behind eye; supralabials below eye nearly white; chin and throat white except for some pigment on three anterior infralabials and mental; a series of dark dorsal blotches, slightly diagonal, each blotch with a transverse black line in its middle; edges of blotches darker extending down on sides to first or second scalerow; on first and second scalerows a series of white spots usually covering two scales; these may touch dark blotches or the intervening lighter fawn color. On tail, blotches proportionally longer; intervening light areas very small; venter nearly white with some fine scattered pigment increasing somewhat, posteriorly and becoming dense under posterior part of subcaudal region. A black dashlike spot on outer part of each ventral which together form two black stripes extending to vent level. Anteriorly dots separated a little, and if they occur on tail they are very indistinct.

Measurements in mm.: Total length, 524; tail, 136; width of head, 8.5; length of head, 11.2.

Distribution: I have seen only a single Thai specimen—this from the province of Pattani. It has been reported as occurring in Malaya in the following states: Malacca, Kelantan, Pahang, and Selangor. It also occurs in Singapore, Sumatra, Borneo, Java, and Amboina.

Variation: The range of ventrals is from 250 to 279; of subcaudals from 114 to 168. The loreal is sometimes absent, and the preocular may reach the frontal. The temporals may be $3 + 3 + 3$ or $2 + 2 + 3$. Occasionally the third supralabial may be excluded from the orbit.

Remarks: The species may, according to Tweedie (*loc. cit.*), reach a length of seven feet. The specimen here described is a

juvenile collected at Bukit Besar by Nai Pryoon Kananuracks of Na Pradoo, Pattani.

Tweedie, Dec., 1954, has reported the species from Kelantan northern Malaya. He further distinguishes two color patterns in the species, neither of which fits the description here given.

Boiga multomaculata (Boie)

(Fig. 65)

Dipsas multomaculata Boie, *in* Boie, Isis, 1827, p. 549 (type-locality, Java); Russell, Indian serpents, 1801, vol. 2, p. 27, pl. 23 (Java).

Dipsas multimaculata: Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 265, pl. 11, figs. 4, 5; Abbildungen neuer oder unvollständig bekannter Amphibien . . . 1844, pl. 14, figs. 13-15; Boulenger, The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 360; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 923; Günther, The reptiles of British India, 1864, pp. 311-312.

Dipsadomorphus multimaculatus: Boulenger, Catalogue of the snakes of the British Museum, 2nd Ed., vol. 3, 1896, pp. 63-64; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 346; 1901, p. 615; Wall, Journ. Bombay Nat. Hist. Soc., vol. 13, 1901, p. 534; *ibid.*, vol. 29, 1924, p. 869; *ibid.*, vol. 30, 1925, p. 818; *ibid.*, vol. 31, 1925, p. 564; Prater, Journ. Bombay Nat. Hist. Soc., vol. 38, 1935, p. 201; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 168-169.

Boiga multimaculata: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 203; Pope, The reptiles of China, 1935, pp. 330-331, pl. 15, D-I; Bourret, Les serpents de l'Indochine, 1936, p. 311; M. Smith, The fauna of British India, Ceylon and Burma; Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 347-348; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1142-1143.

Boiga multimaculata hainanensis Mell, Lingnan Sci. Journ., vol. 8, 1929, p. 213 (type-locality, Hainan).

Boiga multimaculata indica Mell, Lingnan, Sci. Journ., vol. 8, 1929, p. 213 (type-locality, Continental India).

Diagnosis: Relatively small species of the genus, approximately one meter in length; body slender, compressed. Maxillary teeth, 9(10) + 2. Scalerows: 19, 19, 15; preocular not reaching top of head. Gray above with two series of dark, light-edged spots on dorsum and two irregular series on sides; venter cream, heavily clouded or spotted with light brown; a short line behind eye.

Description of species (from No. 33490, Ang Hin, Chon Buri province): Head strongly distinct from neck; rostral distinctly wider than high, only a very narrow portion of it visible from above; internasals as long as broad, as long as prefrontals but narrower; prefrontals much wider than long; frontal very short, as wide as long, its length about equal to its distance from rostral, shorter than parietals; nostril between two nasals, posterior one somewhat concave; loreal present, about as long as high; preocular relatively

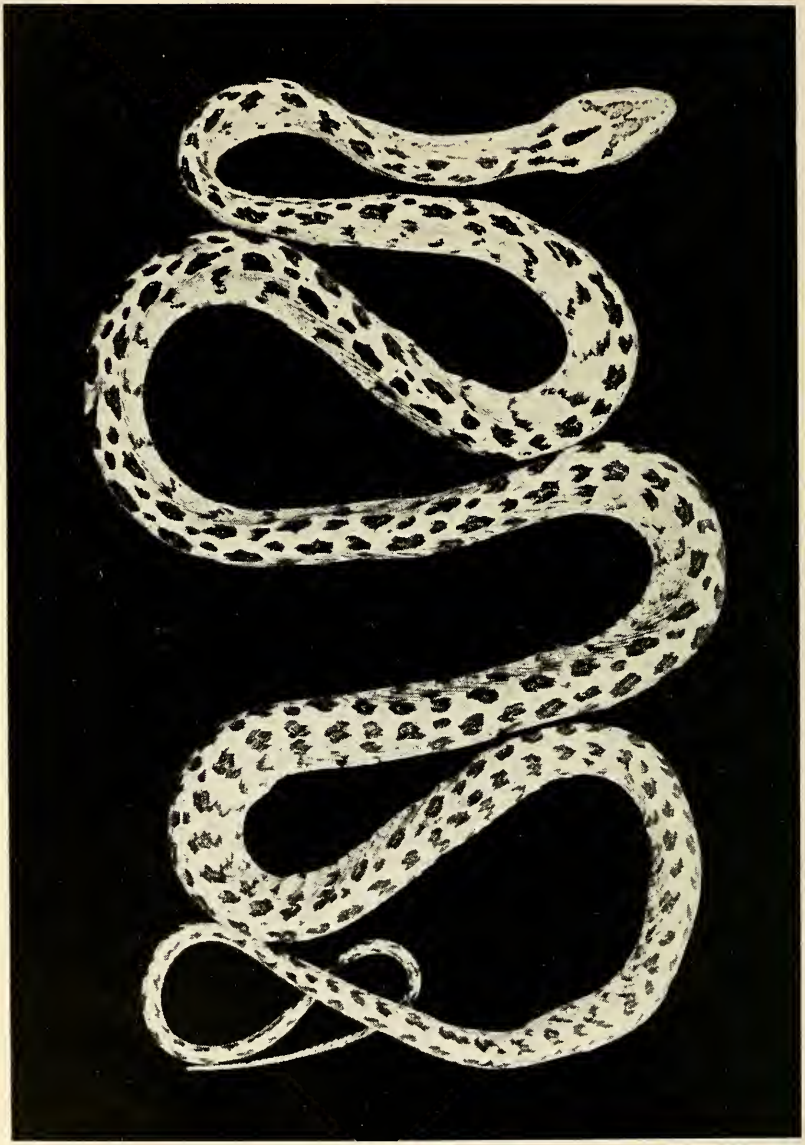

FIG. 65. *Boiga multomaculata* (Boie). No. 3 ♀, Forestry Station, Doi Suthep, 1000 m., Chiang Mai province. Actual total length, 801 mm.; tail, 161 mm.

small not reaching top of head; two postoculars; temporals (normally), 2 + 3 + 3, the front part of upper anterior one broken into two small portions; supralabials eight, third, fourth, and fifth border orbit; eye large, pupil vertical; infralabials eleven, five bordering anterior chinshields which are nearly double size of second pair; latter separated by small scales.

Scale-formula: 27 (occiput), 19, 19, 15, the scales smooth, somewhat diagonal, each with a single apical pit. Ventrals, 235; anal, single; subcaudals, 95; ventrals not or but very obtusely keeled.

Color in life: Brownish gray above with a more or less paired series of large brown spots, darker on their periphery, at least partially, with a narrow creamy-white border; on sides a series of irregular spots or blotches usually alternating with dorsal spots; below another irregular series of smaller spots or flecks; an irregular series of brown spots on outer edge of ventrals, visible laterally; head gray with a brown stripe beginning somewhat behind parietals and running forward, meeting its fellow on frontal; an oval dark spot on occiput; a narrow line from eye across angle of mouth; small indefinite brown flecks on supralabials which are cream on their lower edges; infralabials cream, each with a small brown spot; chin and beginning of throat cream-white; venter brownish gray, spotted or clouded with brown spots or flecks.

Measurements in mm.: Total length, 773; snout to vent, 621; tail, 152; width of head, 11; length of head, 18.

Table of data on Boiga multomaculata

NUMBER	33490 ♀ *	33416 ♀	33229 yg.
Total length	773	801	332
Tail	152	147	72
Head length	18	20	11.5
Head width	11	13.5	8
Ventrals	235	241	229
Subcaudals	95	98	104
Supralabials	8	7–8	8
Infralabials	11	9–9	10 (–11)

* 33490, 33229, Ang Hin, Chon Buri; 33416 Phu Kading (Mt.) Loei province.

Variation: No. 33416 ♀ is a specimen collected on Phu Kading (plateau) by Dr. Kloom Vajropala at an elevation of 4000 feet. The specimen is anomalous in that there is remarkable fusion of the head scales. The internasals are fused into a single scale, the left supraocular and parietal are partially fused on one side, the

upper preocular and supraocular are fused on the other; the second, third, fourth, and fifth supralabials on the right are completely or partially fused into one scale; on the left side the second and third are partially fused, the third excluded from the border of the orbit. The scale-formula: 31 (occiput), 17, 17, 13.

The vertebral scalerow is distinctly enlarged, and the posterior border usually has a small emargination. The spots on head do not join together, and they terminate on the parietals. The occipital oval spot is present, flanked by two smaller diagonal spots. The infralabials usually have several brown flecks rather than a single discrete spot. The maxillary teeth in the two larger specimens number 9 + 2.

Distribution: In Thailand I have collected the species in Chiang Mai (Doi Suthep, 1000 m.); and at Ang Hin, Chon Buri province at near sea-level. One anomalous specimen has been taken on Phu Kading 1210 m. Loei province. Other specimens have been reported from certain islands in the Gulf of Siam. It is also known in Burma, Assam, Indo-China, southern China, Hainan, Java, Sumatra and Borneo.

Boiga cyanea Duméril, Bibron, and Duméril

(Fig. 66)

Triglyphodon cyaneum Duméril, Bibron and Duméril, Erpétologie générale, vol. 7, pt. 2, 1854, pp. 1079-1080 (type-locality, not given).

Dipsas cyanea: Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, pp. 361-362; Evans Journ. Bombay Nat. Hist. Soc., vol. 13, 1901, p. 553; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 188.

Dipsadomorphus cyaneus: Boulenger, Catalogue of the snakes in British Mus., vol. 3, 1896, p. 72 (*part.*); Evans, Journ. Bombay Nat. Hist. Soc., vol. 16, 1904, p. 170; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 329; *ibid.*, vol. 19, 1909, p. 353; Rec. Ind. Mus., vol. 3, 1909, p. 154; Smith and Kloss, Journ. Nat. Hist. Soc. Siam, vol. 1, 1915, p. 246.

Boiga cyanea: Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1924, p. 873; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 64-65; Bourret, Les serpents de l'Indochine, vol. 2, 1936, p. 317; Smith, The fauna of British India, Ceylon and Burma; Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 355-356; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1143-1145, fig. 28.

Diagnosis: Scalerows normally, 21, 21, 15; vertebral scales somewhat enlarged; body compressed; adults nearly uniform green above; yellowish cream on venter and subcaudal region. Anterior palatine teeth scarcely larger than posterior; anterior mandibular teeth much larger than posterior.

Description of species (from No. 34887, environs of Ubon, Ubon province): Rostral a little wider than high, only a very small por-

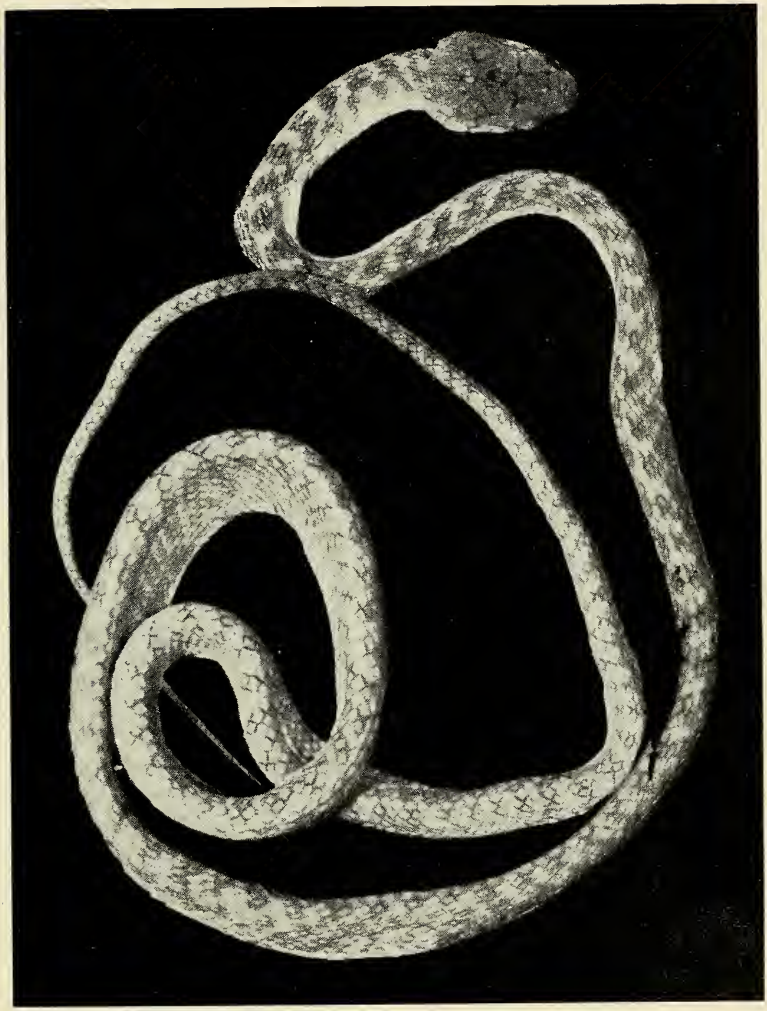

FIG. 66. *Boiga cyanea* Duméril, Bibron and Duméril. EHT-HMS No. 31826, Lomlo Mt. 2100 m. elev., Loei Ban Maeo, Ko Sathon, Dansai, Loei, Thailand. (Young.) Actual total length, 700 mm.; tail, 161 mm. (From Taylor and Elbel.)

tion visible above; internasals distinctly wider than long; prefrontals wider than long, their common suture longer than that between internasals; frontal shorter than its distance from tip of snout, shorter than parietals; nostril between two nasals, anterior the larger; loreal a little longer than high; preocular large, reaching top of head but separated from frontal; two postoculars; temporals, 2 + 3 + 3; supralabials nine, third, fourth, and fifth bordering

orbit; infralabials, 11-12, five touching first chinshields which are broader, but a little shorter, than second pair; latter separated by small scales. Scale-formula: 28 (occiput), 21, 21, 15. Scales smooth in somewhat diagonal transverse rows with a single apical pit in dorsal scales; body scales somewhat pointed behind; vertebral scalerow enlarged, the scales truncate behind. Ventrals, 249; anal, single; subcaudals, 125. Lateral keel on ventrals indistinct. Pupil vertical.

Color in life: Above uniform green; below, on venter and in subcaudal region, yellowish cream; bluish or bluish-white on chin. In preservative nearly ultramarine below, edges of scales lighter.

Measurements in mm. (measurements taken on the described specimen are no longer available): The species is known to reach a length of 1869 mm. (*fide* M. Smith). A specimen reported by Taylor and Elbel (*loc. cit.*) has a total length of 1558, the tail, 311 mm.

Variation: The ventrals are known to vary from 237 to 257; subcaudals, 144 to 158.

Distribution: In Thailand the species is known from Nakhon Lampang; Loei (Ban No Muang, elev. 1780 m., Na Haeo, Phu Lom Lo, elev. 2100 m.). A specimen has been taken on Koh Pa-Ngan (island) and one at Klong Menao in Trad province, southeastern Thailand.

Remarks: The specimen described was taken from a cavity in a tree limb about two meters above ground. It made no effort to bite when captured or when handled later. Taylor and Elbel (*loc. cit.*) figure a specimen showing the juvenile coloration pattern, all or almost all of which is lost in the adult. The color in life of the adult is a lively emerald- or yellow-green which tends to become bluish green or bluish in preservative.

Boiga dendrophila (Boie)

Boiga dendrophila Boie, Isis, vol. 20, 1827, p. 549 (type-locality, Java).

Boiga dendrophila dendrophila: Brongersma, Zool. Meded, Deel, 17, 1934, pp. 205-207.

Brongersma has reviewed this species, (*loc. cit.*) and has recognized eight subspecies, only one of which is known to occur in Thailand. The species has a wide range, from Luzon in the Philippines, to southern Thailand.

Boiga dendrophila melanota (Boulenger)

(Fig. 67)

Triglyphodon melanotus Bleeker, (museum labels).

Triglyphodon dendrophilum var. C. Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, pt. 2, 1854, p. 1090 (type-locality, Sumatra).

Dipsas dendrophila: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 923 (Catalogue of the reptiles of the Malay Peninsula, 1847, p. 76); Blanford, Proc. Zool. Soc. London, 1881, p. 215.

Dipsadomorphus dendrophilus var. *melanotus* Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, pp. 70-71 (type-locality, "East Coast of Sumatra"). Brongersma,* Contributions to Indo-Australian Herpetology, 1934, pl. 1, figs. 4, 9; pl. 1, figs. 8, 9.

Dipsadomorphus dendrophilus: Flower, Proc. Zool. Soc. London, 1896, p. 889; *ibid.*, 1899, pp. 601, 606 (*part.*); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, 1917, p. 197 (*part.*). Brongersma and Wehlberg, Misc. Zool. Sumatra, vol. 79, 1933, p. 4.

Boiga dendrophila Barbour, Mem. Mus. Comp. Zool. Harvard Coll., vol. 44, 1912, p. 125 (*part.*); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 65. Sworder, Singapore Nat., no. 2, 1922, p. 66.

Diagnosis: Large snake reaching a length of from two to two and one-half meters; deep black with yellow lateral bars extending to venter but not crossing it; labials yellow, edged with black; bars of yellow on body, 23-29, not meeting on mid-line; ventrals, 202-231; subcaudals, 93-109. Maxillary teeth largest, followed by two grooved fangs, anterior teeth largest; 21-23 scalerows around middle of body. Preocular reaching top of head but not touching frontal.

Description of species (from No. 34831, near Phatthalung, Phatthalung Province, Thailand): Head very distinct from neck; snout longer than diameter of eye; rostral as high as wide, narrowly visible above; internasals considerably smaller than prefrontals, laterally separated from loreal; prefrontals wider than long, touching nasal, loreal, and preocular laterally; frontal short, shield-shaped, shorter than its distance from tip of snout, shorter than parietals; supraoculars subtriangular; parietals as broad as long; nasal divided, posterior portion rather concave and bearing nostril; loreal longer than high; preocular narrowly separated from frontal; two small postoculars; temporals, 3 + 3 (2 + 3) second series not regular; supralabials, 8-8, third, fourth, and fifth border orbit; sixth and seventh largest; infralabial, 11-11, five touching first chinshields which are larger than second; latter scales triangular, touching only at a point, but touching labials throughout their length. Body compressed.

* The type locality "Sumatra" is restricted by Brongersma, 1934, *loc. cit.*, to "the east coast of Sumatra."

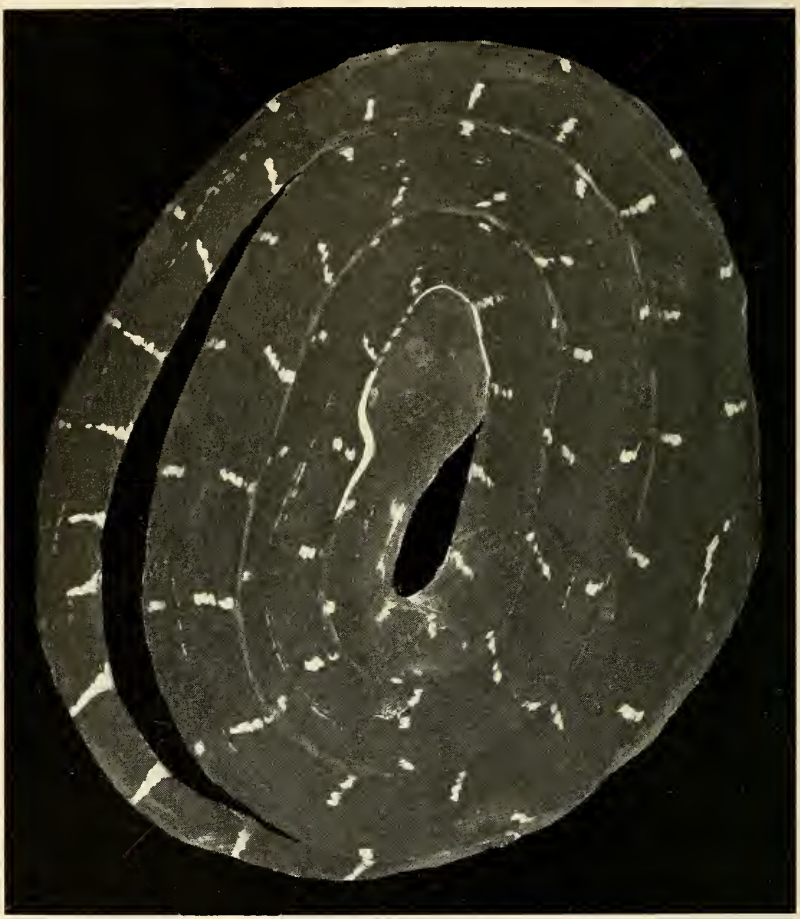

FIG. 67. *Boiga dendrophila melanota* (Boulenger). No. 34828, 6 km. east, Phatthalung, Phatthalung province, Southern Thailand. Actual total length, 1795 mm.; tail, 374 mm.

Scale-formula: 26, 23, 21, 15; scales smooth, with two apical pits; vertebrals enlarged; scales arranged in diagonal transverse rows. Ventrals, 218; subcaudals, 99; anal, single. Ventrals somewhat angulate.

Color in life: Deep black or blue-black with narrow bright yellow bands mostly confined to sides, reaching venter, where they widen but do not cross. Head black above; labials yellow with black sutures; chin and front part of throat yellow; first yellow band covering outer parts of three ventrals, and farther back cov-

ering rarely more than outer part of one ventral, extending on scale for a third of its width. Subcaudal bands widen on venter often completely crossing subcaudal region.

Measurements in mm.: Total length, 1308; tail, 258; width of head, 29; length of head, 37.

Variation: Ventrals vary between 209 and 239; the subcaudals, 89-110. Occasionally nine supralabials are present instead of eight.

Distribution: In Thailand the species has been taken in Pattani, Phatthalung, Trang, Narathiwat, and Nakhon Si Thammarat provinces, all in the southern part of peninsular Thailand.

Remarks: I have followed Dr. Brongersma's (*loc. cit.*) arrangement of the subspecific forms of this species. He regards this form as being confined to the peninsula and the coast of Sumatra. The species itself has a wide distribution also in the Indo-Australian Archipelago and the Philippines.

The serpents were usually found in trees that overhung streams. At Phatthalung I captured three from a single tree. When first disturbed they slid into the water, swam under its surface for some distance but reappeared later on the opposite bank.

Boiga nigriceps (Günther)

Dipsas nigriceps Günther, Ann. Mag. Nat. Hist., ser. 3, vol. 12, 1863, p. 359 (type-locality unknown).

Dipsadomorphus nigriceps: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 72-73, pl. 3, fig. 3; The vertebrate fauna of the Malay Peninsula; Reptilia and Batrachia, 1912, pp. 171-172.

Dipsadomorphus pallidus Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 164, fig. (type-locality, Bukit Besar, Jalor [= Pattani province, Thailand]).

Boiga nigriceps: M. Smith, Bull. Raffles Mus., no. 3, Apr., 1930, p. 64; Tweedie, The snakes of Malaya, 1954, p. 76.

Dipsas Hoffmanseggi Peters, Mon. Akad. Wiss. Berlin, 1867, p. 27 (type-locality, Java).

Dipsas flavescens var. Jan *in* Jan and Sordelli, Iconographie générale des ophidiens, vol. 3, livr. 38, pl. 5, fig. 2.

Diagnosis: Scales in 21 rows at middle, median row enlarged; snout longer than eye. Subcaudals more than 114; one preocular very close to or touching frontal; no ventral stripes.

*Description of species** (after Boulenger, *loc. cit.*, 1912, p. 171-172): Anterior palatine and mandibular teeth enlarged. Snout

* This species is represented by a single specimen from Thailand taken in Jalor [= Pattani] and described by Boulenger (*loc. cit.* 1903) as *Dipsadomorphus pallidus*. This subsequently was placed in the synonymy of *Boiga nigriceps* by Boulenger (1912).

longer than eye. Rostral broader than deep; frontal as long as broad, or a little longer than broad, as long as its distance from end of snout, shorter than parietals; loreal as long as deep or longer than deep; one preocular, in contact with or narrowly separated from frontal; two postoculars; temporals, 1 + 2, 2 + 3, or 3 + 3; eight upper labials, third, fourth, and fifth entering orbit; four or five lower labials in contact with anterior chinshields, which are usually shorter than posterior. Scales in 21 rows, vertebral row strongly enlarged. Ventrals, 240-263; anal, entire; subcaudals, 140-154.

Color: Head uniform blackish or purplish grey above; body reddish or pale greyish brown, uniform or irregularly mottled with darker, sometimes with the dorsal series of small black spots; upper lip and lower parts yellowish-white; belly and tail often speckled with gray.

Measurements in mm.: Total length, 1650; tail, 410.

Distribution: The species is known in Thailand only in the province of Pattani (Bukit Besar). It occurs in Borneo, Java, and Malaya.

Boiga jaspidea Duméril, Bibron, and Duméril

(Fig. 68)

Dipsas cynodon (*part.*) Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 269.

Triglyphodon jaspideum Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, pp. 1093-1097 (type-locality, Java).

Dipsas fusca (*non* Gray) Motley and Dillwyn, Cont. Nat. Hist. Labuan, 1855, p. 48, pl. (type-locality, Labuan, Borneo).

Dipsas boops Günther, The reptiles of British India, 1864, p. 309, pl. 24, fig. G. (type-locality, Bengal?); F. Müller, Verh. nat. Ges. Basel, 7, 1882, p. 151.

Dipsas jaspidea: Jan, Elenco Syst. Ofid., 1863, p. 104.

Dipsadomorphus jaspideus: Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, p. 73; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 170-171 (Java, Borneo, Malaya and Singapore).

Boiga jaspidea: Sworder, Singapore Nat., no. 2, 1922, p. 66, Singapore; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 64, (key to Malayan *Boiga*); Tweedie, Snakes of Malaya, 1953 (also 1954), p. 76 (Jasper Cat-Snake).

Diagnosis: A large arboreal snake reaching a length of about one and one-half meters; scales in 21 (rarely 23) rows at middle of body, median row enlarged; preocular touching frontal; one or two preoculars, two postoculars; temporals, 2 + 2.

Description of species (from EHT-HMS, No. M. 22, Maxwell's Hill, Perak, Malaya): Head distinct from neck, body compressed;

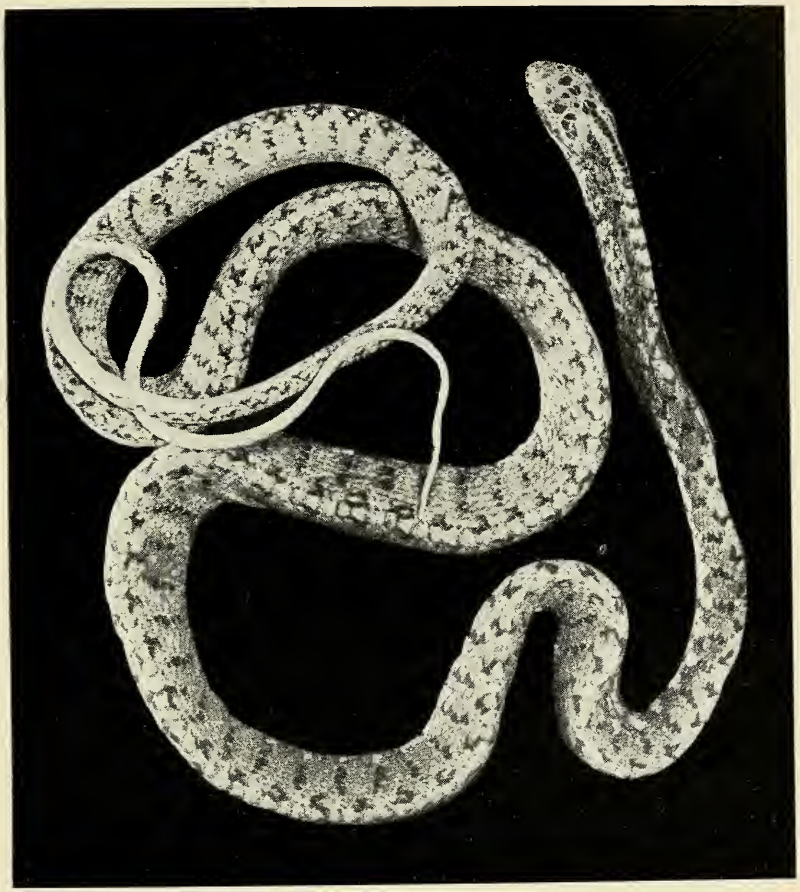

FIG. 68. *Boiga jaspidea* Duméril, Bibron and Duméril. EMT-HMS No. M 22, Maxwell's Hill, Malaya. Actual total length, 838 mm.; tail, 213 mm.

rostral distinctly broader than high, narrowly visible from above; internasals broader than long, touching only nasals laterally; prefrontals broader than long touching nasal, loreal, preocular, but not supraocular; their common suture distinctly shorter than that between internasals; frontal large, about as broad as long (5 mm. x 5.2 mm.), longer than its distance to tip of snout, about five sixths as long as parietal; latter nearly as wide as long (5.4 x 6 mm.); nasal not or only partially divided, more or less deeply concave in posterior portion, which is distinctly larger than anterior; loreal small, distinctly higher than long; two preoculars, upper large, reaching upper surface of head and touching frontal; supraocular

much widened posteriorly, practically as long as frontal; two postoculars, upper much the larger; temporals, 2 + 2; upper anterior temporal touching postoculars; eight (nine on left side) supralabials, third, fourth, and fifth bordering orbit, last longest; eye large, its diameter equal to its distance from rostral.

Mental triangular wider than rostral; infralabials, 12-12, five touching first chinshields which are about same size as second pair; latter separated by scales; first pair also separated by a narrow scale; one pair of scales between chinshields and first ventral.

Median scalerow enlarged, the scales broader than long; scales smooth, without apical pits, forming diagonal transverse rows; scalerow-formula: 27 (occiput), 19, 23, 17. Ventrals angular laterally but not keeled or notched; ventrals, 259; anal, single; subcaudals, 155, all divided except terminal scale.

Teeth: Maxillary, eight subequal; mandibular, 16 diminishing slightly in size posteriorly.

Color: Above brown to olive-brown with a median series of irregular black flecks or spots, often paired with lighter areas between; lateral series of vertical bars or spots usually not contiguous with median spots, but touching small cream spots ventrolaterally that are situated on outer scalerow and outer edge of ventrals; a series of subquadrangular black spots, closely spaced anteriorly, but fewer posteriorly and less distinct, often separated by three unspotted ventrals; entire ventral surface yellowish with fine black spots on chin and throat. Anterior part of venter without pigment; latter two thirds with a fine peppering of brownish pigment, becoming thicker posteriorly; subcaudal region also heavily pigmented, while tail is generally marked like body. Most head scales with more or less symmetrical light-edged black spots, and an inch-long nuchal black stripe from parietals; supralabials light with black spots on sutures.

Measurements in mm.: Snout to vent, 625; tail, 213; total, 838; length of head, 16; width of head, 11.

Distribution: A single specimen of this species has been taken in Thailand by Nai Prayoon Kananuracks at Na Pradoo, Pattani. Elsewhere it is known from Borneo, Java, Malaya and Singapore.

Variation: The ventrals are known to vary between 243 and 267; the subcaudals from 140 to 166. There may be one or two preoculars and the labials are either eight or nine. The color in life is often reddish brown speckled with black and pink, sometimes with black and pink bars. (*fide* Tweedie, *loc. cit.*).

Boiga cynodon (Boie)

(Fig. 69)

Dipsas cynodon Boie, Isis, 1827, p. 559 (type-locality, Java); Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 268, pl. 11, figs. 10, 11; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 924; Catalogue of Malayan Reptiles, 1847, p. 77 (*part.*); Günther, The reptiles of British India, 1864, pp. 308-309; Jan and Sordelli, Iconographie générale des ophidiens, vol. 3, livr. 38, 1871, pl. 6, fig. 1 (Sumatra); Sclater, Journ. Asiat. Soc. Bengal, vol. 60, 1891, p. 244; Boettger, Abh. Mus. Dresden, 1894-95, no. 7, 1895, p. 4.

Opetioden cynodon: Duméril, Bibron, and Duméril, Erpétologic générale . . . vol. 7, pt. 2, 1854, pp. 907-911.

Eudipsas cynodon: Fitzinger, Systema Reptilia, Fasc. 1, 1843, p. 27; Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858, p. 168.

Dipsadomorphus cynodon: Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, pp. 78-80 (*part.*); A vetebrate fauna of the Malay peninsula . . . 1912, p. 172.

Boiga cynodon: Griffin, Philippine Journ. Sci., sec. A, 1909, no. 4, p. 599 (Palawan); Stejneger, Med. Zool. Mus. Kristiania, vol. 2, 1922, p. 82; Taylor, Snakes of the Philippine Islands, 1922, p. 206; Sworder, Singapore Naturalist, 1923, p. 67; Taylor, Philippine Journ. Sci., vol. 22, no. 5, 1923, p. 553; Wall, Journ. Bombay Nat. Hist. Soc., 1924, p. 874; Sworder, Singapore Naturalist, 1924, p. 20; *ibid.*, 1924, p. 22; M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 65; Mertens, Abh. Senck. naturf. Ges., vol. 42, 1930, p. 315; Bourret, Les serpents de l'Indochine, vol. 2, 1936, pp. 318-320, fig. 129 (after Jan and Sordelli).

Diagnosis: Large snakes exceeding two meters in overall length; head very distinct from neck; body very strongly compressed; anterior palatine and mandibular teeth much enlarged; one preocular, two postoculars; three supralabials enter eye; scales in 23-25 rows at mid-body; vertebral scales much enlarged; ventrals, 245-292; anal, entire; subcaudals, 116 to 159. Yellowish fawn or pale reddish brown with dark brown or black transverse spots often enclosing a light median spot; a black streak on head behind eye.

Description of species (from No. 1718): Rostral about as broad as high, scarcely visible above; internasals moderate (injured in this specimen); prefrontals large, a little broader than long, frontal about as long as wide, shorter than its distance from tip of snout and shorter than parietals; a triangular depression on head following frontal formed by the elevation of the parietals; parietals distinctly longer than wide; nasal divided, nostril a vertical slit; loreal longer than high, touching three supralabials; a large preocular narrowly separated from frontal; supraocular distinctly narrower than frontal; two postoculars, upper largest, touching parietal and first upper temporals; temporals, $3 + 3$ on right side, $\frac{1}{2 + 3}$

FIG. 69. *Boiga cynodon* (Boie). No. 1718, Forest Experimental Station Khao Chong, Trang province. Actual total length, 2490 mm.; tail 515 mm.

on left side; supralabials, 9-9, third, fourth, and fifth border orbit; mental narrower than rostral; anterior chinshields broader but shorter than second pair; infralabials, 13-14, five border on first chinshields; second chinshields in contact for about half their length.

Scale-formula, 27, (occiput), 25, 23, 15, median row enlarged except on neck; scales smooth with paired apical pits; ventral scales not angulate; ventrals, 282; anal, single; subcaudals, 143.

Color: Above generally fawn to a bright reddish brown above with a series of transverse bands on back, irregular anteriorly, most bands enclosing lighter areas on middorsal line, which cover three

or four vertebral scales; remaining scales of the black spots may have lighter centers at middle of body; these bands separated by from three to five centimeters farther back; dark bands and intervening lighter areas are about same size; on tail, bands darker, while intervening light areas may be only one fifth as wide as dark band. Neck brownish yellow below; remainder of venter clouded grayish brown with indistinct lighter spots along outer edge of ventrals; subcaudal region dark, clouded with black and white spots. Head nearly uniform light reddish brown, labials lighter; a sharply defined black stripe extending from eye to near jaw-angle.

Measurements in mm.: Snout to vent, 1975; tail, 515; total length, 2490; length of head, 52; width of head, 27.5.

Variation: There seems to be no intermediate individuals showing a mixture of the color patterns of this and the blackish form described herein, despite the fact that both forms occur in the same area. It would seem that they are distinct populations each maintaining its own characteristics, but of this I am not certain.

Distribution: So far as I am aware, the blackish form has not been obtained north of Na Pradoo, Pattani, nor south of Singapore, while the typical form described above has a range from Assam and Burma, south through Thailand, Malaya and to the islands of the Indo-Australian Archipelago as far as the Philippines.

Another uniformly fawn-colored form occurs in Borneo and Mindanao together with the typical one. The blackish form does not occur there so far as is known.

Boiga cynodon var. (Boie)

Dipsadomorphus cynodon var. B., Boulenger, Catalogue of the snakes of the British Museum, vol. 3, 1891, pp. 78-80 (Malacca).

Boiga cynodon (part.): Tweedie, The snakes of Malaya, 1854, p. 77 ("a melanistic variety is not uncommon").

Diagnosis: Characters of typical *cynodon* but dark brown or blackish; venter blackish.

Description of species (from P.K. No. 100, Na Pradoo, Pattani south Thailand): Head very distinct from body; body compressed; rostral a little wider than high with a very narrow triangular portion visible above; internasals a little broader than long, touching only nasal laterally; prefrontals broader than long, touching nasal, loreal, and preocular laterally; frontal a little longer than broad (7 mm. × 9 mm.); distinctly shorter than its distance from tip of snout, shorter than parietal; width of parietal (9 mm.) less than

length, (11 mm.); nostril large, nasal small, partially or completely divided, posterior portion more or less concave; loreal one and one-half times as long as wide; preoculars large, reaching upper surface of head, failing to reach frontal; supraocular four fifths as wide as frontal; two postoculars, upper touching parietal; temporals, 3 + 3 (irregular on right side); nine supralabials, eighth largest, fourth, fifth, and sixth bordering orbit; eye large, pupil vertical, its diameter about equal to its distance from nasal.

Mental broad, equal to width of rostral; two pairs of chinshields, posterior slightly the larger; twelve infralabials, four touching first pair of chinshields, five (or four) touching second pair; one pair of small scales between first ventral and second chinshields; scales smooth without apical pits.

Scalerow-formula: 33 (about occiput), 25 on neck, 23 middle, 15 before vent; vertebral series enlarged; transverse scale series forming diagonal rows. Ventrals, 279; anal, single; subcaudals, 156, divided, except terminal scale.

Teeth; maxillary and palatal teeth injured; mandibular teeth 17, the first three or four large, curved, fanglike; others diminishing in size; last nine subequal.

Color (in preservative): Above generally black with about 22 gray blotches on latter three fourths of body and a row of cream or ivory ventrolateral spots, alternate ones being fused with gray blotches; on anterior fourth of body a few blotches of cream outlined by skin color where scales are separated; tail with 28 bands (or spots, as some bands are broken); head black, much flecked with lighter color; labials light with black spots on sutures; chin and neck ivory, flecked with gray-black; farther back the black soon covering venter and subcaudal area except that the posterior edge of each ventral has a fine whitish edge.

Measurements in mm.: Total length, 2040; tail, 497; with of head, 26; length of head, 45.

Distribution: A single specimen captured at Na Pradoo, Pattani, southern Thailand by Nai Prayoon Kananuracks has been the only Thai specimen available for study. Outside of Thailand this form has been reported from Malaya and Singapore.

Genus *Dryophis* Dalman

Dryophis Dalman, Analect. Entomology, 1823, p. 7 (substitute name for *Dryinus Merrem,* preoccupied; type of genus, *Coluber nasutus* Merrem, designated by Boie, Isis, 1827, p. 519).

Passerita Gray, Ann. Phil. (new series), vol. 10, 1825, p. 208 (also a substitute name for *Dryinus;* type of genus, *mycterizans*).

Tragops Wagler, Natürliches System der Amphibien, 1830, p. 184 (type of *genus, rasinus*).

Herpetotragus Fitzinger, Systema reptilia, 1843, p. 27 (type of genus, *nasuta*).

Diagnosis: Slender elongate snake with rather sharply pointed head; maxillary teeth very unequal, first five increasing in size, closely followed by two ungrooved fanglike teeth; and following a diastema, seven smaller equal-sized teeth preceding two enlarged grooved fangs. Head distinct from neck with sharp canthus; scales smooth in 15, 15, 13 rows the scales also in diagonal transverse rows; eye transversely oval with horizontal pupil.

Three species of this genus enter our territory. They may be differentiated by the following key:

KEY TO THAI SPECIES OF *Dryophis*

1. Snout with a pointed dermal appendage, extending far beyond the lower jaw, and formed from rostral scale with, rarely, small separate scales at base ..... *nasuta*
   Snout lacking a pointed dermal appendage 2
2. Ventrals 194-235, subcaudals 151-187, anal divided ..... *prasinus*
   Ventrals 186-195; subcaudals 136-156, anal single ..... *mycterizans*

The snakes of this genus are arboreal. In the Philippines they are called *dahun palay* (the leaf of rice), and feared. They are often found on bushes at from five to six feet elevation and are reputed to strike at the eyes of passers-by. They bear a very marked superficial resemblance to species of *Oxybelis* a genus of arboreal serpents in the Western Hemisphere.

Dryophis prasinus Reinwardt, *in* Boie

(Fig. 70)

Coluber nasutus Russell, A continuation of an account of Indian serpents . . . vol. 2, 1801-1809 (1801), p. 28, pl. 24 (type-locality, Java) (not *C. nasutus* of de Lacépède).

Dryophis prasinus Reinwardt, *in* Boie, Isis, 1827, p. 545 (type-locality, Java); Flower, Proc. Zool. Soc. London, 1896, p. 890, *ibid.*, 1899, p. 682; Boulenger, The fauna of British India including Ceylon and Burma . . . Reptilia and Batrachia, 1890, p. 369; Catalogue of the snakes of the British Museum, 2nd Ed., vol. 3, 1896, pp. 180-182; A vertebrate fauna of the Malay peninsula . . . Reptilia and Batrachia, 1912, p. 175; Wall, Journ. Bombay Nat. Hist. Soc., vol. 17, 1906, p. 7; *ibid.*, vol. 19, 1909-10, pp. 353, 834; *ibid.*, vol. 29, 1924, p. 877; de Rooij, The reptiles of the Indo-Australian Archipelago, Ophidia, vol. 2, 1917, pp. 206-207, fig. 79; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, 1920, p. 97; Rec. Indian Mus., vol. 42, 1940, p. 484. Bourret, Les serpents de l'Indochine, 1936, p. 330; Bull. Instr. Pub. Hanoi, 1939, p. 28; Shaw, Shebbeare and Barker, Journ. Bengal Nat. Hist. Soc., vol. 16, 1941, p. 62; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1147-1148 (Loei province).

Passerita prasina: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 66; Sworder, Singapore Nat., no. 2, 1922, p. 67.

Ahaetulla prasina: Stejneger, Copeia, 1933, p. 203; Pope, The reptiles of China . . . 1935, pp. 322-324, pl. 13, figs. J, K, L, M, N, O.

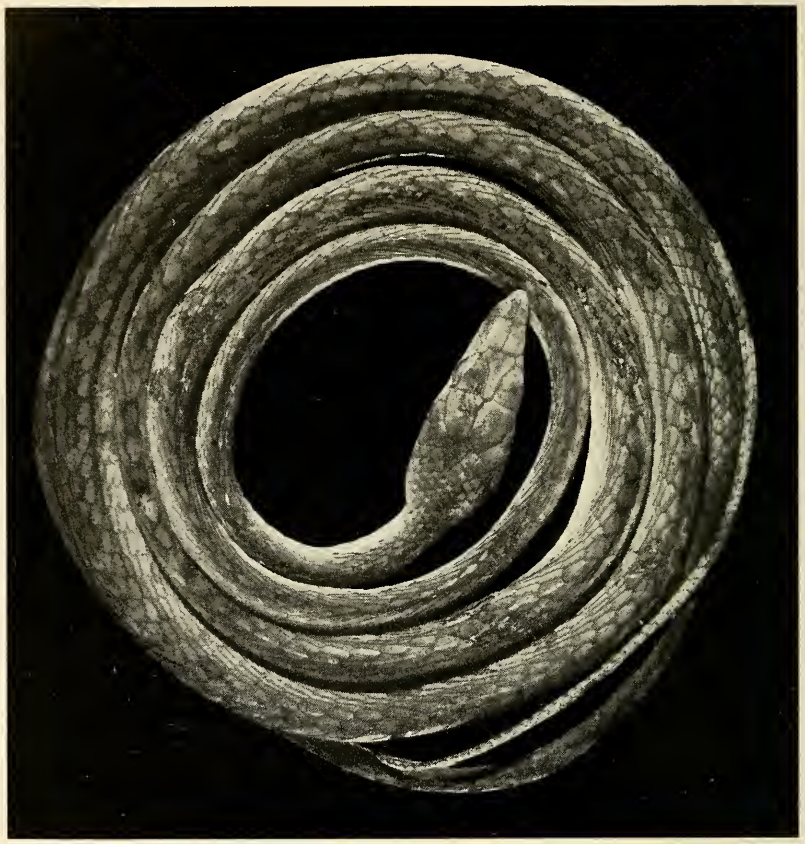

FIG. 70. *Dryophis prasinus* (Reinwardt, *in* Boie). No. 36534, Doi Suthep, Chiang Mai province, northern Thailand. Actual total length, 1388 mm.; tail, 450 mm.

Dryophis prasinus flavescens Smith, Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, p. 785 (type-locality, Trang, Thailand).

Dryophis prasinus indicus Mell, Sitzungsb. Ges. Nat. Fr. Berlin, 1930, p. 323 (type-locality, India).

Dryophis prasinus chinensis Mell, Sitzungsb. Ges. Nat. Fr. Berlin, 1930, p. 323 (type-locality, China).

Diagnosis: Head elongated, distinct from neck; snout pointed; rostral with a free edge above, but not bearing a distal dermal appendage; snout at least twice as long as eye; canthus rostralis sharp; no horizontally divided labials; anal normally divided. Scales of males keeled in region above vent; three labials border orbit; ovoviviparous.

Description of species (from No. 33658, Chiang Mai): Rostral nearly ventral directed forwards and upwards, only upper free edge visible from above; internasals narrowed anteriorly about one and three-fourth times as long as wide; prefrontals bending down sharply at canthus, total width more than half their length; frontal widened anteriorly then much narrowed posteriorly, its widest part less than width of supraoculars, its length less than its distance from tip of snout, approximately as long as parietal or a little longer; nasal small, pointed behind nostril in posterior part of scale; two small loreals on one side, absent on other side; large preocular bent across canthus and bordering frontal, strongly convex; two postoculars; temporals, 1 + 2 + 2; supralabials, 8-9; on right side lower part of fourth labial joins third thus leaving a second "preocular," and which with the two following labials enters orbit; on left side three labials enter orbit; infralabials, 8-8, four touching first chinshields, which are wider but considerably shorter than second pair.

Scale-formula: 19 (occiput), 15, 13. Scales elongate, smooth throughout (keeled in males in region of vent) and arranged in oblique transverse rows, the median longitudinal row somewhat enlarged. Ventrals, 209½, subcaudals, 177. Ventrals keeled, often with a small notch where scale bends up; cream marks under chin. On maxillary, eighth and ninth teeth suddenly enlarged and fanglike, followed after several small teeth by two grooved fangs. The third and fourth teeth in dentary, fanglike, abruptly enlarged.

Color in life: Yellowish green or leaf green above, interstitial skin black and white forming oblique lines; ventrals paler green with a yellowish or whitish line along keels on each side of ventrals.

Measurements in mm.: Snout to vent, 934; tail, 526; width of head, 13.7; length of head, 36.

Variation: Two or three loreals may be present, (rarely absent); temporals, 2 + 2 or 2 + 3; ventrals vary between 194-235; subcaudals, 165-187 ♂ ; 151-172 ♀ . Usually two anals, rarely one. The species is variable in color, and green, gray, cream, fawn or yellow specimens may appear. These variants do not seem to be geographical in their distribution.

Distribution: The species is common in Thailand occurring probably in most of the provinces. Outside of Thailand very widespread from Sikkim through Southeastern Asia, the Malay peninsula and islands of the Indo-Australian Archipelago.

Dryophis mycterizans (Linnaeus)

Coluber mycterizans (Linnaeus), Systema naturae, Ed. 10, 1758, p. 226 (type-locality, "America" *ex errore*); Andersson, Bih. Sven. Vet. Akad. Stockholm, vol. 24, 1898, 4, 6, p. 14

Dryophis xanthozona Boie, Isis, 1827, p. 545 (type-locality, Java); Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, p. 180; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 175 (Trang).

Dryinus prasinus (*part.*): Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 928.

Passerita xanthozonia: M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 66.

Diagnosis: A slender snake, snout twice as long as eye; prefrontals twice as long as broad; supralabials not horizontally divided; no dermal appendage on tip of snout; anal, single.

Description of species: Snout pointed, feebly projecting without appendages, about twice as long as eye; internasals in contact with rostral; frontal a little longer than its distance from end of snout, as long as parietals; a series of three or four small loreals; one preocular, in contact with frontal, two postoculars; temporals, 2 + 2; eight or nine supralabials, fourth and fifth, or fourth, fifth, and sixth entering orbit; four infralabials touching anterior chinshields which are much shorter than posterior.

Scalerow-formula: 15, 15, 13; the transverse rows of scales disposed obliquely; vertebral row slightly enlarged; ventrals, 186 to 195; subcaudals, 132-156; anal, single.

Color: Usually green, grayish green, or grayish; interstitial skin black and white; venter whitish; a white line along outer margin of ventrals, heavily edged inside with green or gray; sometimes a median ventral line of white; throat white.

Measurements in mm.: Total length, 1080 ♀ ; tail, 410.

Distribution: Known in Thailand only from Trang province and Tasan, near the Isthmus of Kra. Outside of Thailand it is known from Java and Malaya.

Remarks: The name *xanthozona* was for a long time applied to this form but an examination of the Linnean type specimen by Andersson shows that the name *xanthozona* is a synonym of *mycterizans*, a name that had long been applied to the *Coluber nasutus* of Lacépède.

Dryophis nasutus (Lacépède)

(Fig. 71)

Coluber nasutus Lacépède, Histoire naturelle des serpents, vol. 2, 1789. Discourse and table methodique, p. 100, 277-279, pl. 4, fig. 2 (type-locality, Ceylon, restricted by Taylor and Elbel, 1958).

Dryinus oxyrhynchus Bell, Zoolog. Journ., vol. 2, p. 326 (type-locality, India).

Dryinus russellianus Bell, *ibid.*, p. 327 (type-locality, India).

Dryophis nasutus: Andersson, Bih. Sven. Vet. Akad. Stockholm, vol. 24, 1898, 4, 6, p. 15; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 376-378, figs. 118, 119; Taylor, Univ. Kansas Sci. Bull., vol. 33, pt. 2, Mar. 10, 1950, p. 581; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1148-1149.

Passerita nasuta: Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 32.

Ahaetulla nasuta: Stejneger, Copeia, 1933, p. 203.

Coluber mycterizans: (*non* Linnaeus) Russell, An account of Indian serpents collected on the coast of Coromandel . . . vol. 1, 1796, pp. 16, 18, pls. 12, 13 (type-locality, Vizagapatam, India).

Dryophis mycterizans: Boulenger, The fauna of British India, Ceylon and Burma . . . Reptilia and Batrachia, 1890, pp. 370-371, fig. 108; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 182; Finn, Journ. Asiat. Soc. Bengal, vol. 47, 1898, p. 66; Alcock and Rodgers, Proc. Royal. Soc. London, vol. 7, 1902, p. 446; Kinnear, Journ. Bombay Nat. Hist. Soc., vol. 21, 1912, p. 1336; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, pt. 3, March, 1915, pp. 174, 187, 214 (Bangkok); Wall, Journ. Bombay Nat. Hist. Soc., vol. 16, 1905, pp. 308, 542; pl., *ibid.*, vol. 26, 1909, p. 572; Wall, The snakes of Ceylon, 1921, p. 291; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 172. Bourret, Les serpents de l'Indochine, 1936, p. 333; Cains, Journ. Bombay Nat. Hist. Soc., vol. 26, 1919, p. 862; McCann, Journ. Bombay Nat. Hist. Soc., vol. 32, p. 1928, p. 612, *ibid.*, vol. 37, 1934, p. 226; Fraser, Journ. Bombay Nat. Hist. Soc., vol. 39, 1937, p. 484; Shaw, Shebbeare and Baxter, Journ. Bengal Nat. Hist. Soc., vol. 16, 1941, p. 63; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, p. 307 (Chiang Mai, Thailand).

Dryophis mycterizans anomalus Annandale, Mem. Asiat. Soc. Bengal, vol. 1, 1906, p. 196 (type-locality, Ramanad, S. India); Wall, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910, p. 524.

Drypohis mycterizans tephrogaster Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 783 (type-locality, Burma).

Dryophis mycterizans zephrogaster Wall, *ibid.*, vol. 20, 1909, p. 229 (type-locality, Burma).

Dryophis mycterizans cinereoventer: Wall, *ibid.*, vol. 18, 1908, p. 919 (error ? possibly meant for *tephrogaster*).

Dryophis mycterizans rhodogaster Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 919 (type-locality, Schwebo, Upper Burma).

Dryophis mycterizans lepidorostralis Wall, *ibid.*, vol. 20, 1910, p. 229 (type-locality, Bengal).

Dryophis mycterizans isabellinus Wall, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910, p. 230 (type-locality, Paralai near Valpari Anamallai Hills).

Dryophis mycterizans rhodonotus Wall, The snakes of Ceylon, 1921, p. 293 (type-locality, Galatura Estate, Ceylon).

Diagnosis: Slender arboreal snake, with a dermal process on lip of snout extending far beyond lower jaw and formed wholly from rostral scale; no loreal present; sharp canthus rostralis; length of snout (without appendage) usually 2½ to three times length of eye; one preocular touching frontal; normally eight supralabials, third and fourth entering orbit. Usually green, but may be pinkish, fawn, yellowish, leaden, gray, brown, etc.

Description of species (from No. 786 Bangkok): Rostral narrow, attenuated as if pulled forward and bent back over tip of snout

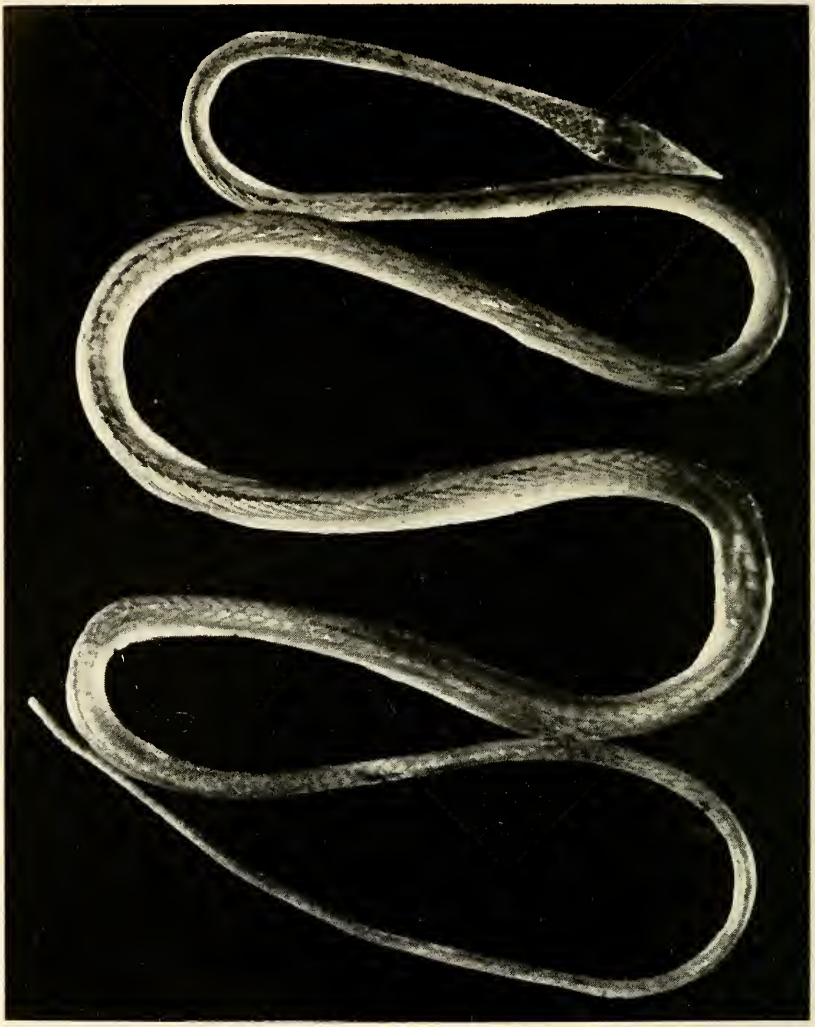

FIG. 71. *Dryophis nasuta* (Lacépède). No. 786 Bangkok (city). Actual total length, 998 mm.; tail, 358 mm.

with dorsal and lateral grooves. Nasals greatly elongated forming two lateral crests in contact or minutely separated in front of internasals; nostril pierced in posterior end of nasal; internasals longer than nasals, more than twice as long as wide, pointed anteriorly, outer portion extending behind nasal and in contact with two supralabials; prefrontals touching labial, only a little longer than wide; canthus rostralis strongly marked; preocular concave, bordering frontal; frontal scarcely as wide as supraoculars, much nar-

rowed posteriorly, its length less than its distance from rostral, its length equal or slightly greater than parietal; no loreals; two postoculars, upper largest; temporals, 2 + 2 + 2, lower primary temporal small; eight supralabials, first elongate and pointed anteriorly, fourth divided into three parts leaving what appears to be a lower preocular and a subocular, both bordering orbit; the following (fifth) labial also enters orbit; infralabials, 10-9, four bordering first chinshields, which are wider but much shorter than posterior pair.

Scalerows: 24 (occiput), 15, 15, 11. Ventrals, ♀ 193; anals, 2; subcaudals, 155.

Color: Brown (in life, green) with chin cream; a cream ventrolateral line to tip of tail. Venter purplish, probably a shade of green in life; interstitial skin cream.

Measurements in mm.: Total length, 998; tail, 358; head width, 8.7; head length, 27.7.

Remarks: This species, long known as *Dryophis mycterizans,* is identical with Lacépède's *nasutus;* the type-specimen is not *mycterizans* of Linnaeus.

The snake is somewhat remarkable for its appearance in very different colors. Many of these color forms have been named but seemingly they are not geographical and may appear anywhere in its range. These may be buff, fawn, gray, yellowish, bluish, brown, pink, rose, etc.

Distribution: In Thailand it occurs in the central and northern parts but it is not known whether it reaches down into the peninsula any great distance. It has been taken as far north as Doi Suthep, Chiang Mai province.

It is known also in Ceylon, India and Burma.

Genus *Dryophiops* Boulenger

Dryophiops Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 193-194 (type of genus, *Dipsas rubescens* Gray).

Diagnosis: Body very slender, compressed; head elongate, distinct from neck; pupil of eye horizontal; nasal undivided; frontal narrow, bell-shaped; scales unkeeled, oblique, in 15 rows; ventrals and divided subcaudals each with lateral keels and notches. Maxillary teeth 20, subequal, last two or three enlarged and grooved; anterior mandibular teeth enlarged.

Two species are recognized, one occurring in Thailand. The other presumably is confined to the Philippines.

Dryophiops rubescens (Gray)

(Fig. 72)

Dipsas rubescens Gray, Illustrations of Indian Zoology, vol. 2, 1834, pl. 84, fig. 2 (type-locality [probably], Malay Peninsula).

Leptophis rubescens: Blyth, Journ. Asiat. Soc. Bengal, vol. 23, 1855, p. 293.

Chrysopelea rubescens (part.): Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858, p. 145; The reptiles of British India, 1864, p. 299.

Dryophis rubescens: Jan and Sordelli, Iconographie générale des ophidiens, livr. 32, 1869, pl. 6, fig. 1.

Dryophiops rubescens: Boulenger, Catalogue of the snakes in the British Museum, Ed. 2, vol. 3, 1896, p. 194; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 176 (Penang, Siam, Sumatra, Borneo, Mentawei and Natuna Islands); Smedley, Malayan Nat., vol. 2, no. 1, p. 47 (Changi, Singapore); Taylor, Philippine Journ. of Sci., vol. 26, no. 1, 1925, pp. 110-111 (Peñon de Coron, Philippine I.); Tweedie, The snakes of Malaya, 1954, p. 82 (Singapore to Kedah and Kelantan).

Diagnosis: See generic description; also differs from *Dryophiops philippina* in having an elongate loreal scale.

Description of species (B.M. No. 1912.2.22.21, Kelantan, Malaya): Rostral more than twice as broad as high, narrowly visible from above; internasals nearly as wide as prefrontals, but much shorter laterally, touching only nasal; prefrontals longer than broad, their common suture not quite twice length of that between internasals; frontal narrow, bell-shaped, anteriorly only a little wider than supraocular, its length greater than its distance from tip of snout, shorter than parietals; parietals large, followed by a median enlarged postparietal scale; nasal small, undivided, wedge-shaped; loreal slender, elongate; preocular large, reaching upper surface of head and in contact with frontal; supraocular larger in area than frontal; three postoculars; temporals, 2 (3) + 2 + 2; supralabials nine, fourth to sixth bordering eye; seventh largest; mental with a smaller labial border than rostral; first labials in contact behind mental; ten infralabials, first five in contact with first chinshields, which are much shorter than second pair; latter in contact with each other nearly entire length.

Ventrals, 202½; anal, divided; subcaudals, 149, divided; both ventrals and subcaudals with lateral keels and notches.

Scale-formula: 21 (occiput), 15, 15, 11; the median and outer rows somewhat largest; others narrow, oblique.

Color: Above gray with fine flecks and marbling; a median irregular series of small black spots, the row often broken; head somewhat olive, flecked with darker and lighter, this color extending somewhat onto neck; chin and throat yellowish, the color extending some inches on underside of body; an irregular brownish stripe

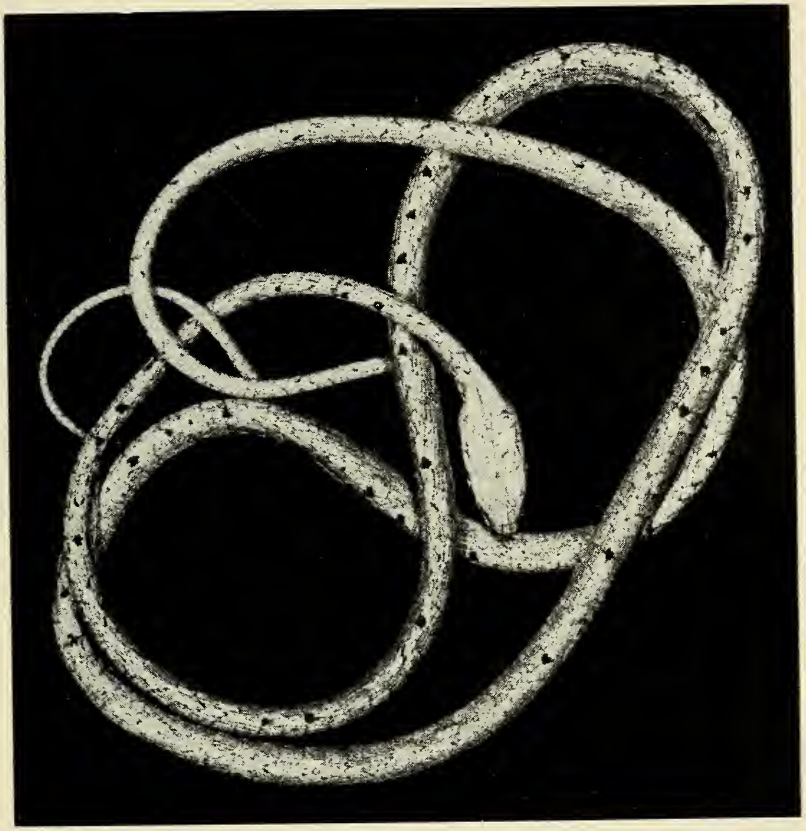

FIG. 72. *Dryophiops rubescens* (Gray). B.M. No. 1912.2.22.21, Kelantan, Malaya. Actual total length, 646 mm.; tail, 200 mm.

from tip of snout through eye continuing some distance on neck, the lower edges darker (blackish or brownish); most of area of supralabials, cream-white.

Measurements in mm.: Snout to vent, 446; tail, 200; total length, 646; width of head, 7; length of head, 14.

Variation: A specimen is at hand (EHT-HMS, No. 3863) that I collected in 1961 at Na Pradoo, Pattani. The color differs in being generally bronzy reddish-brown to magenta above, the scales showing larger or smaller darker diagonal areas which results in indefinite spotting. The venter is somewhat rubescent with some scattered flecks and a peppering of grayish black. The stripe from snout through the eye is present; and the chin and throat are somewhat yellowish.

The ventrals number 193; the anal is divided; the subcaudal, 141. There is a flattening on the snout, more noticeable in this specimen than in the one described. The snout is brownish. However, in both specimens there is a dim light stripe from tip of snout to frontal, its edges a little darker than adjoining color.

I examined four Chulalongkorn University specimens, recently acquired as a gift from Nai Prayoon Kananuraks, taken at Na Pradoo, Pattani. These present the following data:

Table of data of Thai *Dryophiops rubescens*

NUMBER	Sex	Total length	Tail	Ventrals	Subcaudals
CU. 2579.....	♀	744	218	198	125
CU. 2580.....	♂	765	217	200	131
CU. 2581.....	♀	762	215	190	122
CU. 2582.....	♀	836	223	197	121

Some of the specimens show a light line across the supraoculars with or without darker flecks, or a darker line with white flecks; in two specimens the supraoculars were slightly wider than the frontal; two postoculars are present rather than three. The temporals are, 2 + 2 + 2 increasing in size posteriorly. If apical pits are present (so stated by Boulenger), they are difficult to discern.

The type in the British Museum, No. 1946.1.9.62 accompanied by a specimen of *Draco taeniopterus* has been examined. It shows three enlarged scales behind the parietals. The specimen contains the remains of a *Hemidactylus frenatus.**

Distribution: In Thailand specimens are known only from Na Pradoo and the nearby Bukit Besar (Mt.). Elsewhere, it is known from Palawan (Philippine I.), Borneo, Sumatra, Mentawei, Natuna Islands, and Malaya.

Genus *Psammodynastes* Günther

Psammodynastes Günther, Catalogue of the colubrine snakes in the collection of the British Museum, London, 1858, p. 140 (type of genus, *Psammodynastes pulverulentus.*

Anisodon Rosen, Ann. Mag. Nat. Hist., ser. 7, vol. 15, p. 176 (type, *lilljeborgi*).

Diagnosis: A small snake about half a meter in length; head distinct from neck, with an angular canthus rostralis; eye large with a vertical pupil; scales smooth in 17 rows about body at middle. Maxillary teeth, 10-12, arranged as follows: two small

* A label on the jar gives the locality "Bengal" but the place of origin seems to be most probably somewhere in Malaya.

anterior teeth followed by two much larger ones; these followed by an interval, then five or six small teeth, then two enlarged grooved fangs. Hypapophyses on posterior dorsal vertebrae, somewhat variable.

Only two species are known, *pictus* occurring in Borneo and Sumatra, and *pulverulentus* with a very wide distribution from Mindanao in the Philippines through much of the Indo-Australian Archipelago and southeastern Asia to south China and Nepal. The general variations in the form throughout this wide area has seemingly produced no recognized subspecies.

The species is ovoviviparous. Its poison acts quickly on the small reptiles and amphibians upon which it preys, but it is not regarded as dangerous to man. The snake varies remarkably in color pattern, however the same patterns seem to appear in each population.

Psammodynastes pulverulentus (F. Boie)

(Fig. 73)

Psammophis pulverulenta F. Boie, Isis, 1827, p. 547 (type-locality, Java).

Psammodynastes pulverulentus Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 363; Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 172-174; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1907, pp. 204, 330; *ibid.*, vol. 20, 1910, p. 72, pl.; *ibid.*, vol. 21, 1912, p. 686; *ibid.*, 29, 1924, p. 875; *ibid.*, vol. 30, 1925, p. 818; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, pp. 156, 174 (Sai Yoke, Kanchanaburi; Bangkok); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 162; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1915, p. 202 (Siam); M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 267; Bull. Raffles Mus., no. 3, 1930, p. 66 ("Bangnara, Pattani"; Nakhon Si Thammarat); Cochran, U. S. Nat. Mus., vol. 77, 1930, p. 32 "Nong Khor" "Pak Jong" "Lam at Tong Lang"; Sriracha; Nong Nam Kiew; Pran; "Kao Saming"; Khun Tan Mts.); Pope, The reptiles of China, 1935, pp. 324-327; Bourret, Les serpents de l'Indochine, 1936, p. 326; M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 484; Shaw, Shebbeare and Barker, Journ. Bengal Nat. Hist. Soc., vol. 16, 1941, p. 57; M. Smith, The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 368-370, fig. 116-117.

Dipsas ferruginea Cantor, Proc. Zool. Soc. London, 1839, p. 53 (type-locality, Assam).

Lycodon bairdi Steindachner, Reise Novara . . . Reptilia, 1867, p. 90 (type-locality, Philippines).

Anisodon lilljeborgi Rosen, Ann. Mag. Nat. Hist., ser. 7, vol. 15, p. 176 (type-locality, Java).

Diagnosis: Third or fourth maxillary tooth enlarged, fanglike, followed by a diastema; last of series enlarged, fanglike, grooved. Canthus angular, frontal narrow, the nostril in a single nasal.

Description of species (from EHT-HMS No. 13 Frasers Hill, Malaya): Small snakes (630 mm.); rostral wider than high, ap-

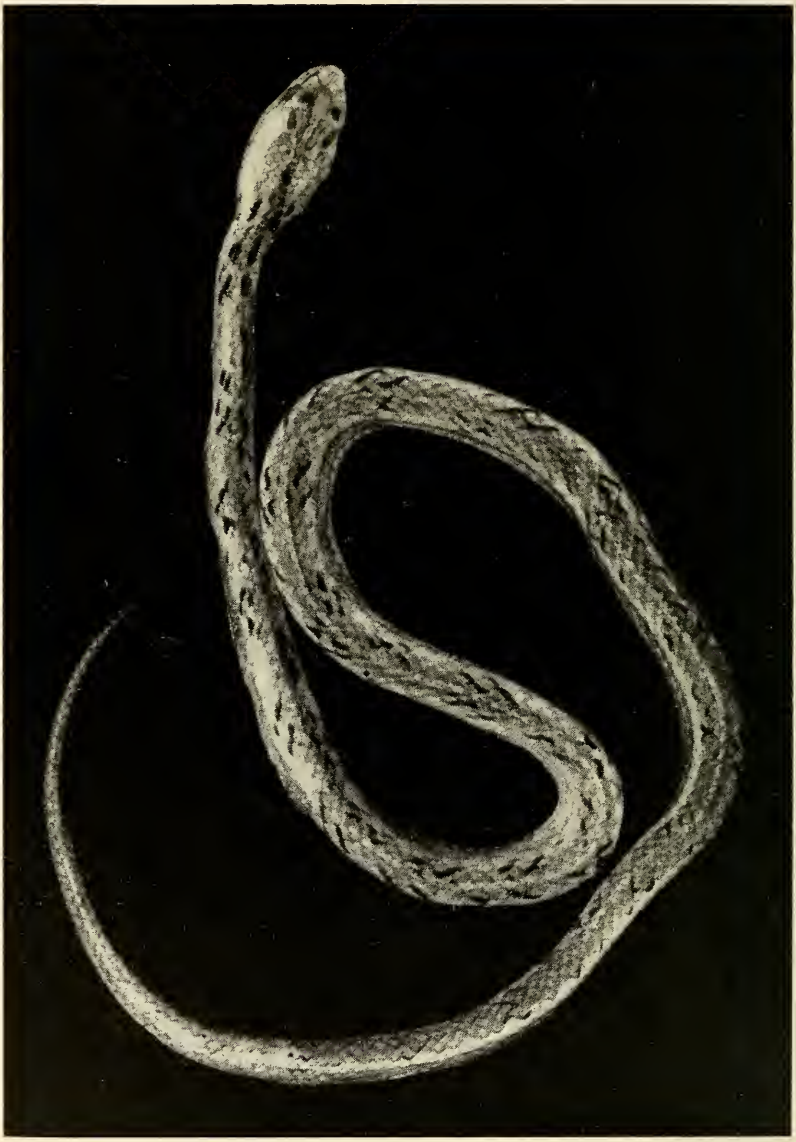

FIG. 73. *Psammodynastes pulverulentus* (Boie). EHT-HMS No. 36014 ♂, Kaeng Pang Tao, Chiang Mai province, Northern Thailand. Actual total length, 521 mm.; tail, 86 mm.

pearing on dorsal surface of head as a line; internasals small, their common suture a little more than half that between prefrontals, their lateral ends turned down below canthus touching loreal; frontal narrower than supraoculars; latter scales extend forward beyond level of eye, notching preocular; parietals about length of frontal, with an entrant suture cutting the scale laterally. Nostril in a single nasal; loreal a little longer than high; a large irregular preocular barely reaching upper surface of head; two postoculars; single anterior temporal, followed by two or three temporals, touching fifth supralabials; nine supralabials, third to fifth bordering orbit; seven or eight infralabials, three touching first chinshields, which are followed by two somewhat smaller pairs of chinshields, all pairs in contact.

Scale-formula: 19, 17, 15; scales smooth, without pits; ventrals, 171, rounded; subcaudals, 74; anal, single.

Color: Five median scalerows dove-gray, bordered on each side by a dark-edged ivory-white line less distinct anteriorly; sides dirty gray-white; on most of body, but growing less numerous posteriorly, are numerous short diagonally placed dots or lines often encroaching on or crossing light lateral line; on neck four narrow lines develop along borders of the white line and extend forward to occiput; where they disappear; a dim median dark line on occiput; lips and side of head light; white on chin, throat, and venter; grayish in subcaudal region.

Measurements in mm.: Snout to vent, 335; tail, 101; total length, 436; width of head, 8.7; length of head, 18.5.

Variation: The snout in old specimens tends to turn up slightly at the tip. The coloration is especially variable. It may be dark, nearly blackish brown with or without dark and light spots, a more or less dark streak on each side of the head passing through eye, and usually a dark brown stripe along sides; below powdered with brown and with dark spots or longitudinal lines. Usually symmetrical markings are evident on the head.

The loreals may be divided. One or two preoculars, and two to four postoculars may be present. The temporals are usually 2 + 3. The ventral count may vary between 146 and 175, the subcaudals, between 44 and 71.

Distribution: In Thailand specimens have been taken in Chiang Mai, Narathiwat, Kanchanaburi, Pattani, Chon Buri, Phrae, Nong Khai, and Nakhon Si Thammarat. It is a mountain form, usually

not occurring much below 2000 ft., although it may reach sea level.

It is known in Indo-China, Southern China, Hainan, northwestern India, and the Indo-Australian Archipelago to the Philippines.

Remarks: The young are born alive. The snake has a poison that is not regarded as dangerous to man. Shaw has reported that a snake, *Rhabdophis subminiata,* struck by one, died in 16 minutes.

Genus *Psammophis* Fitzinger

Psammophis Fitzinger, Neue Classification der Reptilien, . . . 1826, pp. 29-30 (type of genus, *P. sibilans*).

Taphrometapon Brandt, Bull. Acad. Sci. St. Petersburg, vol. 3, p. 243 type, *lineolatus.*

Mike Werner, Sitz. Ber. Akad. Wiss. Wien., vol. 133, p. 51 (type *elegantissimus* = *condenarus*).

Diagnosis: Maxillary teeth 10-13; one or two in middle of series more or less enlarged, fanglike, preceded and followed by a short diastema; last two teeth much enlarged grooved and directed strongly backwards; anterior mandibular teeth strongly enlarged.

Head distinct from neck; angular canthus rostralis; pupil round; scales smooth, more or less oblique in 17 rows (in Oriental forms); ventrals rounded; tail long; paired subcaudals.

A rather large genus, widely distributed in Asia and Africa.

Only one species is known in Thailand, this presumably with a spotty distribution.

Psammophis condenarus Merrem

Psammophis condenarus Merrem, Tentamen systematis amphibiorum 1820, p. 107 (type-locality [based on a plate in Russell], An account of Indian serpents collected on the coast of Coromandel [India], vol. 1, 1796, p. 32, pl. 27 "from Ganjam district").

Malcolm Smith has recognized two subspecies of this serpent, the typical form being confined to parts of India and *P. condenarus indochinensis* which occurs in Thailand.

Psammophis condanarus indochinensis Smith

Coluber condenarus Merrem, Tentamen systematis amphibiorum 1820, p. 107 (Based on Russell, vol. 1, p. 32, pl. 27).

Psammophis condanarus indochinensis M. Smith, The Fauna of British India, including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, December 1943, pp. 364-365 (type-locality, "in Indo-China south of lat. 21°"); Taungyi, Pegu (Burma), Lopburi, Bangkok (Thailand), Phan-rang (Annam).

Diagnosis: A slender snake reaching a meter in length. Scales in 17 rows at middle of body; a pair of enlarged grooved teeth at posterior end of maxilla; anal divided; anterior end of frontal not

twice as broad as middle; nasal incompletely divided. Frontal longer than its distance from end of snout. Four stripes, median absent; a dorsolateral stripe on the sixth, seventh, and eighth rows.

Description of species (from No. 33639, Doi Suthep, Chiang Mai): Head scarcely distinct from neck; rostral a little wider than high, part visible above about one third as long as internasals; latter scales narrowed anteriorly, slightly longer than wide; prefrontals distinctly longer than wide, their common suture approximately twice that between internasals; frontal narrow, elongate, its width at anterior end not twice its narrowest median width; supraoculars wider than frontal; latter longer than its distance from end of snout, longer than parietals; nasal quadrangular only partially divided, touching two labials; an elongate loreal at least one and one-half times as long as wide; a single large preocular reaching top of head, but separated from frontal; postoculars, 2-2, fused to fifth supralabial; temporals, $1 + 2 + 4$ $(1 + 2 + 3)$; eight supralabials, fourth and fifth entering eye; ten infralabials, four touching anterior chinshields which are larger than second pair.

Scale-formula: 27 (occiput), 17, 17, 15-13; scales smooth, transverse rows rather diagonally placed, bearing a single apical pit. Outer row much larger than adjoining row. Ventrals, 170; anal, divided; subcaudals, 73.

The loreal region distinctly concave and canthus rostralis pronounced.

Color: Dark olive with four dark-brown stripes; a dorsolateral one on scalerows six, seven, and eight, separated from its fellow by the slightly lighter colored median row which bears a series of black dots along middle; a lateral band confined to the second row and edges of first and third scalerows; a whitish stripe, black-bordered below, arising on neck, covering outer half of first scalerow and outer edge of ventrals, narrowed on neck and tail; lower parts dark gray, posterior part of each ventral very light gray (in preservative); head dark olive; supralabials lighter with nearly white edges; some of the head scales have lighter edges; lateral stripe continues on to the head through eye, terminating on the snout.

Measurements in mm.: Snout to vent, 345; tail, 100; total length, 445.

Variation: The ventrals vary from 156 to 173, the subcaudals ♂ 75 to 85; ♀ 66 to 75.

Distribution: The species known in Thailand in the provinces of Lopburi and Chiang Mai. Elsewhere it occurs in Burma, and Annam.

Dr. M. Smith points out that the two forms, *C. condenarus* and *C. indochinensis* are separated by large areas where neither subspecies is known.

Specimens are to be found in low shrubs and bushes. Its food is said to consist of small rodents, lizards and frogs. It ascends to elevations of 2000 meters in mountainous areas.

Genus *Chrysopelea* Boie

Chrysopelea Boie, *in* Férussac, Bull. Sci. Nat., vol. 9, p. 237; Isis, 1827, p. 520 (type, *Coluber ornatus*).

Diagnosis: Head somewhat flattened, distinct from neck; scales smooth or weakly keeled with apical pits; ventrals and subcaudals keeled laterally and notched; scalerow-formula: 17, 17, 15. Maxillary teeth 20 to 22, last three or four larger and grooved. Hypapophyses on posterior dorsal vertebrate seemingly may be present or absent.

Two species are recognized as occurring in Thailand, that may be differentiated by the following key:

KEY TO THAI SPECIES OF *Chrysopelea*

1. Hypapophyses absent on posterior dorsal vertebrae. Last ventral shield divided; color green, each light scale with a black median line; head banded in black and yellow; body often banded with black..... *ornata*
   Hypapophyses present throughout vertebral column; black above, each scale with a central yellowish spot; often with a median dorsal series of red or yellow flower-shaped spots..... *paradisi*

These snakes are remarkable in many ways and have gained the name of "flying snakes" perhaps as much for their speed in moving from branch to branch as for their ability to glide after taking off into the air from a high branch. I have seen this behavior on one or two occasions, the snake landing some feet beyond the point of take-off.

Their climbing ability is well known. I have seen a specimen move up the almost completely smooth bole of a tree perhaps 14 to 18 inches in diameter, by folding the body in a series of loops transversely on the bole and clinging while the path of movement was back and forth across this surface, advancing higher and higher with each turn; but the movement was so slow that it seemed scarcely perceptible.

Again, in Ceylon, a specimen of *ornata* was observed on the ground grasping a lizard (*Sitania*). The snake confronted by three

or four persons, crawled backward some four or five feet to a shrub, elevated its tail to a small branch and proceeded to climb up into the shrub backwards all the time holding on to the struggling lizard. Having found a satisfactory position on a branch some six feet from the ground it proceeded to engulf the lizard which by this time had ceased its struggles, perhaps overcome by the snake's poison.

R. Shelford (Proc. Zool. Soc. London, 1906, pp. 227-230, "A note on the 'flying' snakes") reports his experiments with these snakes. He would take them some fifteen to twenty feet from the earth, then permit them to fall and glide, proving beyond question the contention that they are capable of gliding through the air.

Chrysopelea paradisi Boie

(Fig. 73a)

Chrysopelea paradisi F. Boie, Isis, 1827, p. 547 (type-locality, Java): Smith, The fauna of British India, Ceylon and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 254-255; Tweedie, The snakes of Malaya 1954, p. 57, fig. 13a.

Chrysopelea ornata: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 196 (*part.*); Annandale, Journ. Asiat. Soc. Bengal, n.s. vol. 1, 1905, p. 126; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 212, fig. (Siam, etc.)

Diagnosis: Similar in habitus to *C. ornata* but body-scales black with a green spot on each scale, largest ones on lower row of scales; often with a median row of bright red or yellow spots somewhat resembling a flower. Venter yellow-green; ventrals blackedged.

Description of species (from M. Smith): Very similar to *ornata* in squamation. Hypopophyses developed throughout the vertebral column. Black above each scale with a central rounded or ovate-acuminate greenish-yellow spot, and without a vertebral series of red or yellow tetrapetalous spots; pale greenish yellow below, ventrals often edged with black. In some specimens the median spots may have a median stippling.

Tweedie (1954) adds this data: Ventrals, 198-238; subcaudals, 106-139; anal, divided. Scales in 17 rows sometimes feebly keeled; 9 or 10 upper labials, fifth and sixth, or fourth, fifth, and sixth bordering eye.

Remarks: This species is included on M. Smith's statement "Range, the Malay Peninsula, extending up the west coast as far north as Mergui." Also known in Java, Sumatra, Borneo and the Philippines.

FIG. 73a. *Chrysopelea paradisi* Boie. EHT-HMS No. M 322, 2 km. Northeast Kota Tinggi, Johore, Malaya. Actual total length, 774 mm.; tail, 218 mm.

Chrysopelea ornata (Shaw)

(Fig. 74)

Coluber ornatus Shaw, General zoology or Systematic natural history, vol. 3, pt. 2, 1802, based on Seba's *Jaculus Amboinensis perelegans* vol. 2, pl. 7, fig. 1; *Serpens Ceilanica pomposa veste ornata*, vol. 2, pl. 61, fig. 2, and *Serpens Ceilonica elegantissima* Seba, vol. 1, pl. 94, fig. 7. (type-locality "native of some of the West-Indian islands, Martinico et. [*ex errore*] and according to Seba, of the East-Indian islands Ceylon and Java").

Crysopelea ornata: Boie, Isis, 1827, pp. 526, 546; Duméril, Bibron and Duméril, Erpétologie générale . . . vol. 7, pp. 1042-1045; Günther, The reptiles of British India, 1864, p. 298; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 371-372; Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 196-198 *(part.)*; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 1, 1914, pp. 175-176 (Bangkok); Bull. Raffles

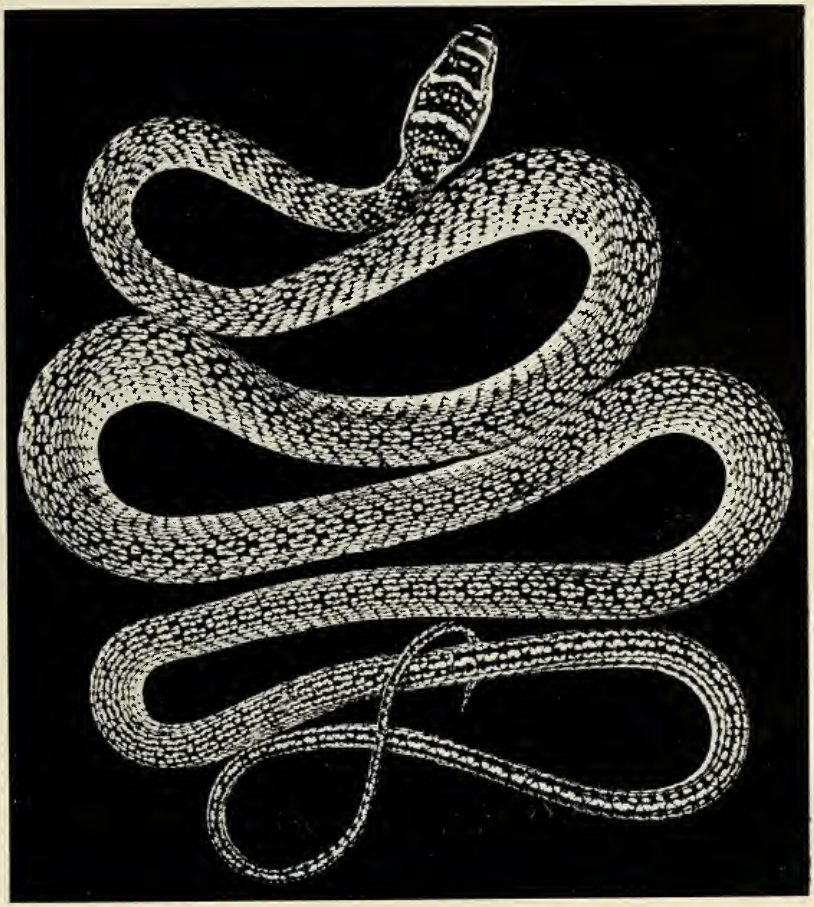

FIG. 74. *Chrysopelea ornata* (Shaw). No. 35127, Udon Thani, Udon Thani province. Actual total length, 1054 mm.; tail, 323 mm.

Mus., no. 3, 1930, p. 66; Rec. Indian Mus., vol. 42, 1940, p. 482; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 33; Bourret, Les serpents de l'Indo-Chine, 1936, p. 321; M. Smith, the Fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 251-254, fig. 86 and 87, B.

Chrysopelea ornata ornatissima Werner, Sitz. Akad. Wiss. Wien, 134, 1925, p. 61 (type-locality, Ankor Wat, Cambodia).

Diagnosis: (See key.)

Description of species (from No. 607, Hua Hin, Prachuap Khiri Khan): Rostral more than twice as wide as high, upper part bent narrowly back above snout; internasals broader than long; prefrontals broader than long, double the area of the internasals; frontal somewhat bell-shaped, longer than wide, its length equal to its

distance from tip of snout, shorter than parietals; nasal divided, loreal three times as long as high; preocular large reaching upper level of head, touching frontal on right side; supraoculars as long as frontal, slightly less wide; two postoculars, upper twice size of lower; temporals, 2 + 2 + 2, upper primary temporal touching both postoculars; five scales between the two upper tertiary temporals; supralabials, 9-9, fifth and sixth bordering orbit; infralabials, 10-10, first five bordering first chinshields which are shorter than second pair; latter touching one another only anteriorly.

Scalerow-formula: 25 (occiput), 17, 17, 13; scales smooth with paired apical pits; ventrals, 222, last one divided; anal divided; subcaudals, 140 paired; both ventrals and subcaudals sharply keeled and more or less notched.

Color in life: Head with narrow greenish yellow and wider black transverse bands; broad parietal band flecked with greenish yellow; chin and supralabials ivory, bordered above by a black line; body greenish yellow each scale with a median black line and a black edge, lines tending to be continuous on back; anteriorly edges of some scales have a wider black border thus producing narrow irregular dark transverse bands; ventrals and subcaudals greenish yellow with small black dots lateral to keel, becoming larger on tail, and a second caudal series of black spots opposite preceding spots but close to inner edge of keel.

Measurement in mm.: Total length, 1068; tail, 330; width of head, 14; length of head, 24.

Variation: There is considerable variation in the coloration of this species. In Ceylon specimens the body as well as the head is banded in black and yellow green, at least anteriorly, with often a series of red or orange dorsal flower-shaped spots. However, Thai specimens I have examined generally follow the above described pattern. Ventrals (*fide* Smith 1943) vary between 213 and 234; subcaudals, 110 and 140, in Thailand and Indo-China.

Distribution: This species occurs widely in Thailand, my specimens being from Prachuap Khiri Khan, Pattani, Chiang Mai, and Udon Thani. It has been reported from Narathiwat, Trat and Koh Chang, an island in the Gulf of Siam. Also widespread in Ceylon, India, Burma and Indo-China.

Subfamily HOMALOPSINAE Jan

Homalopsinae Jan, Elenco sist. ophid., 1863, p. 74.

Diagnosis: Nostrils valvular, on upper surface of snout. Hypapophyses developed throughout the vertebral column; maxillary teeth decreasing in length posteriorly followed by grooved poison-fangs. Tails not compressed.

This subfamily is confined to southeastern Asia, the Indo-Australian Archipelago, Australia, and the South Pacific Islands.

Representatives of six of the Asiatic genera occur in Thailand and two others, *Fordonia* and *Cantoria* I believe doubtless will be discovered along the west coast, since both have a range from Burma to Malaya; *Cantoria* extends into the Indo-Australian Archipelago, and *Fordonia* is known in Cochin China. The presence of *Gerarda* east of the Malay peninsula is reported here for the first time. The homalopsine snakes are often encountered at mouths of rivers near the sea, or in mangrove areas.

These genera may be differentiated by the following key:

KEY TO THAI GENERA * OF HOMALOPSINAE

1. A pair of soft rostral appendages; scales keeled, the ventrals rather narrow and laterally angulate; two species ..... *Erpeton*
   No soft rostral appendages 2
2. Ventrals rather wider without lateral keels; eyes moderate 3
   Ventrals narrower; body scales smooth with a lateral keel; scalerows 37 to 43, the scales on sides largely separated from each other by skin; eyes very small ..... *Bitia*
3. Nasal shields forming a median suture 4
   Nasal shields separated by an internasal 6
4. Parietals whole; scales smooth or keeled 5
   Parietals broken up; scales keeled ..... *Cerberus*
5. Scales smooth ..... *Enhydris*
   Scales strongly keeled ..... *Homalopsis*
6. Scales in more than 17 rows 7
   Scales in 17 rows, body rather short; head not distinct from neck; tail short ..... *Gerarda*
7. Scales in 25-29 rows; body short ..... *Fordonia*
   Scales in 19 rows, body elongate ..... *Cantoria*

* *Fordonia* and *Cantoria* have not been taken in Thailand but probably occur.

Genus *Enhydris* Sonnini and Latreille

Enhydris Sonnini and Latreille, Histoire Naturelle des reptiles, vol. 4, 1802, p. 200 (type of genus, *caerulea* = *enhydris*).

Hypsicophis Fitzinger, Systema reptilium, 1843, p. 25 (type of genus, *plumbea*).

Diagnosis: Body cylindrical, head somewhat flattened; scales in 19-33 rows; head not or slightly distinct from neck; eye small, pupil vertical; nasals in contact behind rostral; one preocular; one postocular; undivided internasal; a loreal present; scales smooth in 19-31 rows; ventrals widened, subcaudals and anal divided; a suture from nostril to first labial. Maxillary teeth, 10-16, followed by a pair of somewhat enlarged grooved fangs.

Of the genera belonging to the family Homalopsinae, most are monotypic. *Enhydris,* however, has some 17 recognized species that are distributed throughout southern and eastern Asia, the Indo-Australian Archipelago and northern Australia.

KEY TO THAILAND SPECIES OF *Enhydris*

1. Scales in 19 rows, olive to olive-black above; two or three outer scalerows, usually yellow; yellow or white below ..... *plumbea*
   Scales in 21-29 rows 2
2. Scales in 27 or 29 rows; loreal touching internasal; greenish black to olive with yellowish transverse bars or series of spots; below yellow, dark color of back tending to form rings across venter ..... *bocourti*
   Scales in 21-23 rows 3
3. A low ventral count (118-145) 4
   Ventral count higher. Scales in 21 -(23) rows ventrals 141-174; general color pattern above consisting of darker and lighter longitudinal stripes; three darker stripes on yellowish venter ..... *enhydris*
4. Scales in 21 rows, ventrals 118-121; black with lighter dorsal reticulum and cross-bars or rings ..... *smithi*
   Scales in 21 rows; ventrals 116-145. A median dark stripe from head developing indefinite paired spots ..... *jagori*

Enhydris plumbea (Boie)

(Fig. 75)

Homalopsis plumbea Boie, Isis, 1827, p. 560 (type-locality, Java); Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 346, pl. 13, figs. 12, 13; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 948.

Hypsirhina plumbea: Gray, Zoological miscellany, 1842, p. 66; Günther, The reptiles of British India, 1864, pp. 280-281; Theobald, Journ. Linn. Soc., Zoology, vol. 10, 1868, pp. 57-58; Tirant, Notes sur les reptiles et les Batraciens de la Cochinchine et du Cambodge, 1885, pp. 40-41; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 376, figs.; Catalogue of the snakes in British Museum, vol. 3, 1896, pp. 5-6; Flower, Proc. Zool. Soc. London, 1899, p. 675; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia; 1912, p. 160; Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, Mar. 1915, pp. 156, 185 ("near Bangkok," "Sai Yoke district"); *ibid.,* vol. 1, no. 3, p. 213; Annandale, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, pp. 91 (Sea of Singgora); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 181; Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 162.

Enhydris plumbea: Pope, The reptiles of China, turtles, crocodilians, snakes and lizards: Nat. Hist. Central Asia, 1935, p. 315, fig.; Bourret, Les serpents de l'Indochine, 1936, p. 276. (Good recent literature list); Smith, The reptiles of British India, Ceylon and Burma . . . Reptilia and Am-

FIG. 75. *Enhydris plumbea* Boie. No. 34238, Bang Saen, Chon Buri, southeastern Thailand. Actual total length, 302 mm.; tail, 40 mm.

phibia, vol. 3, Serpentes, 1943, pp. 282-283, fig. 122; Tweedie, The snakes of Malaya, 1954, p. 84, fig. 21, a; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1159.

Hypsirhina hardwickii Gray, Illustrations of Indian zoology, vol. 2, pl. 87, fig. 1 (type-locality, Penang).

Diagnosis: Small species reaching length of about 400 mm. Scales in 19 rows at middle of body; internasal single, not touching loreal. Dark blackish olive, three outer scalerows usually yellow; below yellowish.

Description of species (from No. 34238 ♀, Bang Saen, Chon Buri): Rostral twice as wide as high, angular above; nasals large, narrowly in contact behind rostral; transverse nostrils connected by suture to second labial; internasal single, wider than long, not touching loreal; prefrontals distinctly smaller than nasals, broader than wide; frontal pentagonal, sides parallel, length nearly equal to its distance from tip of snout, shorter than parietals; loreal a little higher than long; one preocular not reaching frontal; two postoculars, both in contact with first temporal; temporals, 1 + 2 + 2 (1 + 2 + 3); eight supralabials, fourth and fifth bordering orbit; ten infralabials, five touching first chinshields which are longer than second pair; latter separated by pair of scales; mental small, triangular; scale formula: 25 (occiput), 19, 19, 15. Ventrals, 122; subcaudals, 34; anals, 2.

Color in life: Generally greenish-olive, scales slightly darker on edges; head uniform. Three outer scalerows light, the third with upper edges darkened, and with fine grayish powdering elsewhere on scale. Venter ivory becoming yellow-ivory on latter third; broken row of small blackish spots along median line of venter; tail yellowish ivory with a blackish median line; anterior supra- and infralabials with lavender wash over ivory; posterior labials with much yellow; pigment on infralabials chiefly along sutures; eye dull yellow-brown dusted with darker.

Measurements in mm. (Nos. 34238 and 33304): Total length, 302, 272; tail, 40, 40; head-width, 12, 9.6; head-length, 17, 14.8.

Variation: The described specimen is a female and contains seven rather large eggs, none of which show obvious trace of a developing embryo.

A second specimen from Muak Lek, Sara Buri province is a male. In this there is no trace of the pigment on the three outer scalerows, and no spots on the venter. The anterior labials have but little pigment. The ventrals are 132, the subcaudals, 44. The suture from the nostril touches the first labial.

The known range of ventrals is 120-136; of subcaudals, 22-45. The species is called *ngu pla* in the Thai language.

Distribution: The species is widespread in Thailand. It has been taken in numerous localities and probably occurs over much of the country. It occurs also in Burma, southern China, and Indo-China.

Enhydris bocourti (Jan)

(Fig. 76)

Hypsirhina bocourti Jan, Arch. Zool. Anat. Fis., vol. 3, 1865, p. 258, (type-locality, Bangkok, Thailand); Jan and Sordelli, Iconographie générale des ophidiens, vol. 2, livr. 28, 1868, pl. 5, fig. 2; Flower, Proc. Zool. Soc. London, 1899, p. 676; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 10-11 ("Siam"); A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 161; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 100 (photo and fig.); Pourret, Les serpents de l'Indochine, 1936, p. 290.

Enhydris bocourti M. Smith, Fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 388-389 ("Siam as far north as Paknampo").

Diagnosis: Largest member of the genus. Scales in 27 rows; loreal touching internasal; ventrals, 124-136; maxillary teeth followed by grooved fangs. Head depressed; scales smooth; subcaudals paired.

Description of species (from No. 34490): Rostral a little wider than high, very narrowly visible above as a tiny triangle; nasals in contact on median line, nostril more or less connected by a groove or suture with first supralabial; an azygos internasal posterior to nasals, in contact laterally with loreal; prefrontals small, wider than long, wider than frontal, laterally touching loreal and preocular, normally separated from nasal; frontal two and three-fourths times as long as wide, sides parallel for most of its length; supraoculars wider, and shorter than frontal; latter about as long as its distance from tip of snout, distinctly shorter than parietals; loreal higher than long; a preocular separated from frontal; two postoculars; temporals, 1 + 2 + 3; supralabials, 9-9, fourth bordering orbit, seventh and eighth (or only seventh) divided transversely, sixth highest; infralabials, 15-14, five bordering first chinshields, posterior ones smallest; first chinshields about three times size of second pair which are separated by a pair of scales; mental narrow, triangular.

Scalerow-formula: 32 (occiput), 25 neck, 27 mid-body, 21 preceding vent; scales smooth, imbricate. Ventrals, 138; subcaudals, 34 +; anal, divided.

Color: Above brownish black, most scales with an elongate light spot; a series of narrow transverse light bars across back on eleven median rows of scales, bars usually width of a single transverse scalerow, the bordering scales of the bars black or with smaller light spots; areas between these narrow light rings are darker, and

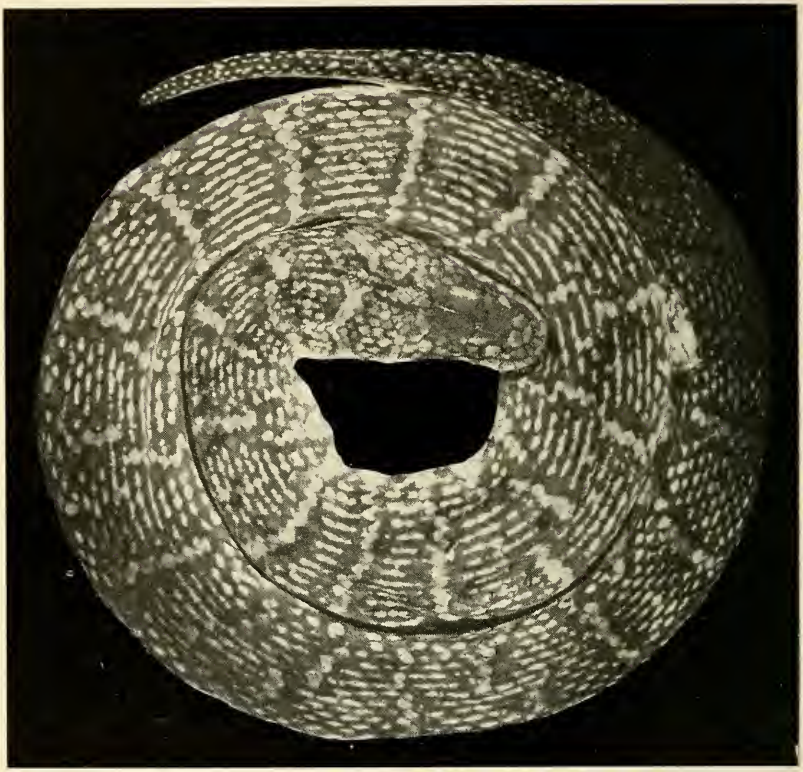

FIG. 76. *Enhydris bocourti* (Jan). No. 34490, Pattani, Pattani province, southern Thailand. Actual total length, 864 + mm.; tail, 102 + mm.

on the sides the lateral parts of two of the dark bands become narrow, forming triangular dark lateral spots from which extends a black bar or stripe about one scalerow in width, which terminates on outer edge of ventrals; from head to tail 31 such bands; lateral triangles with light median spots covering from two to four scales; tail with ten or eleven dorsolateral speckled spots wider than on body; subcaudal area with a median series of elongate dark spots; venter and two or three outer scalerows ivory; edges of scales and ventrals faintly brownish. Head nearly uniform olive above, the scale edges a little darker; supralabials gray on upper parts, ivory on lower parts, the sutures between them black; sutures of some infralabials black with edges of chinshields and adjoining labial edges black; angle of mouth blackish.

Measurements in mm.: (of Nos. 34490 ♀ and 34489 ♀). Total length, 864 +, 807; tail, 102 +, 105; length of head, 55, 53; width of head, 33, 30.

Variation: The largest female in total length measures, 1140 mm.; the tail, 150. The largest male, 620; tail, 100. Ventrals vary between 120 and 140; subcaudals between 36 and 49. The supralabials may be 8-8.

My second specimen (No. 33489 has 140 ventrals, and 40 subcaudals. The coloration is practically identical with the described specimen.

Distribution: In Thailand the species is known from Pattani, and Nakhon Sawan. It has been taken in Bangkok, it also occurs in Cambodia, Cochin China, and the northern part of Malaya.

Remarks: Little is known regarding the effects of the poison of this species but it is not regarded as dangerous to man.

Flower (*loc. cit.*) reports that a female obtained at Kedah in Malaya gave birth to 17 young, their average length being 220 mm. The two specimens from Pattani were obtained by M. L. Pootipong Nupartpat Varavudhi from a pool in that city.

Enhydris enhydris (Schneider)

(Fig. 77)

Hydrus enhydris Schneider, Historiae amphibiorum naturalis et literariae, fasc. primus, 1799, pp. 245-246 (type-locality, Indiae Orientalis [*fide* Russell]).

Hypsirhina enhydris: Günther, The reptiles of British India, 1864, p. 281, pl. 22, fig. k; Boulenger, The fauna of British India, Ceylon and Burma . . . Reptilia and Batrachia, 1890, pp. 376-377; Catalogue of the snakes in the British Mus., vol. 3, 1896, pp. 6-8; Theobald, Journ. Linn. Soc., vol. 10, zoology, 1868, p. 57 (Tonghu, Rangoon); Flower, Proc Zool. Soc. London, 1899, p. 676; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 160; M. Smith, Journ. Soc. Nat. Hist. Siam, vol. 1, no. 2, 1914, p. 100; *ibid.*, vol. 1, no. 2, Aug., 1914, pp. 126-127, 187; *ibid.*, vol. 1, no. 3, Mar., 1915, p. 213; *ibid.*, vol. 2, 1916, p. 162; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 40, 41; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 348; Bourret, Les serpents de l'Indochine, 1935, p. 280.

Enhydris enhydris: Pope, The reptiles of China, 1935, pp. 314-315, pl. 13, figs. D, J; Tweedie, The snakes of Malaya, 1954, pp. 83-84 (Northern Malayan States, Singapore); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, p. 1159; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 383-384.

Diagnosis: One of the larger species of the genus reaching above 800 mm. in total length; scales in 21 (rarely 23) rows; the loreal in contact with the internasal; ventrals, 141-174; markings are longitudinal stripes varying in width and color; below yellow, with three darker lines.

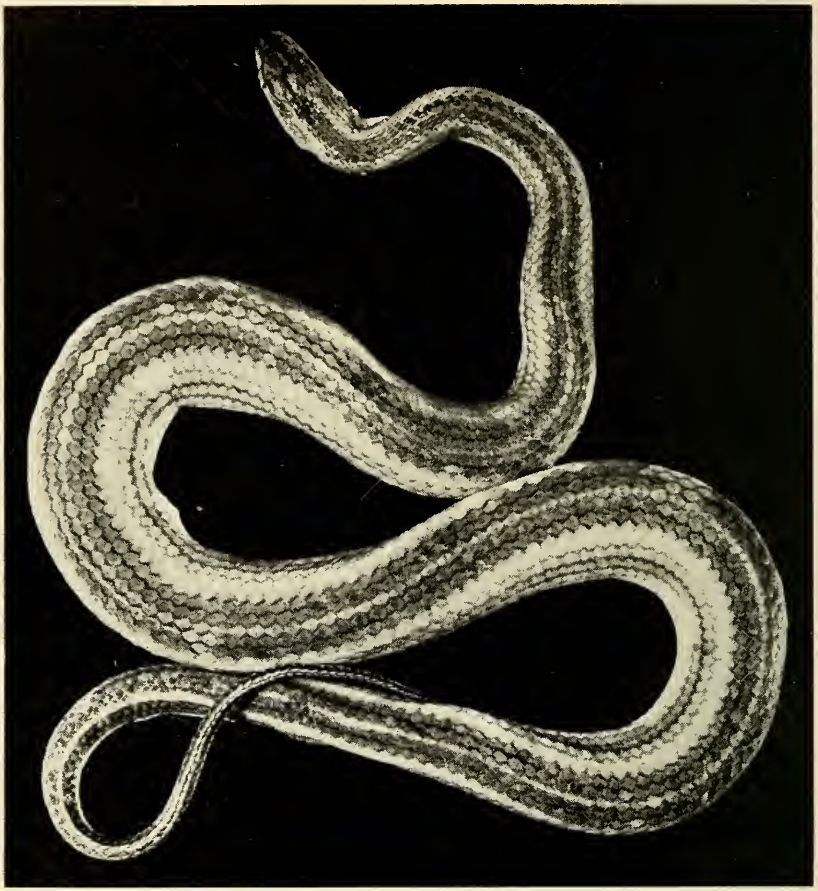

FIG. 77. *Enhydris enhydris* (Schneider). No. 678, Bangkok, Thailand. Total length, 522 mm.; tail, 113 mm.

Description of species (from No. 678): Rostral at least two and one-third times as wide as high, rather narrowly visible above; nasals broadly in contact behind rostral, nostrils (not slitlike) connected by a groove with the first labials; internasal twice as wide as long, in contact laterally with loreal; frontal with sides parallel, pointed rather sharply behind, its length equal to its distance from tip of snout, only slightly shorter than parietals; loreal large, rectangular, touching three anterior labials; a vertical preocular; two postoculars; temporals, 1 + 2 + 3; supraoculars much wider posteriorly; eight supralabials, fourth entering orbit, sixth and seventh largest; nine infralabials, four touching first chinshields; which are shorter and smaller than second pair; latter separated by two pairs of small scales.

Scalerow-formula: 35 (occiput), 25, 21, 21(20). Ventrals, 168; subcaudals, 77; anal, divided. Maxillary teeth, 19(20) + 1, fourth and fifth teeth a little longer and stronger than those preceding the fangs.

Color in life: A broad median gray stripe on body five scales wide, the median scalerow lighter than others; the stripe narrows on neck and at parietals is reduced to a thin line that then widens on frontal to the width of that scale; bordering this broad stripe a narrower light gray stripe on seventh row and parts of two adjoining rows; on neck this is narrowed to two thin lines that outline darker areas on head; on fourth, fifth, and sixth rows a dark gray stripe becoming blackish on tail, that runs forwards on sides of head (including eyes) to tip of snout; three outer scalerows light colored, first, and third nearly white, second gray-white: ventrals yellowish with a gray line on outer edge of ventrals and on edge of first scalerow; another gray line on mid-ventral line; lines on tail blackish and yellowish; dorsal scales with a bluish iridescence.

Measurements in mm. and data on *Enhydris enhydris*

NUMBER*	678♂	679♂	680♂
Total length	522	530	438
Tail	113	118	100
Head, width	10.5	9.2	10
Head, length	17	16.8	17
Ventrals	168	171	164
Subcaudals	77	74	75
Anals	2	2	2
Temporals	1+2+3	1+2+3	1+2+3
Maxillary teeth	19+1	19+1	20+1
	21+1	20+1	22+1
Supralabials	8	8	8
Infralabials	9	9	9

* All from Bangkok.

Variation: The ventrals vary between 141 and 174; the subcaudals between 46 and 77. The scales are occasionally in 23 instead of 21 rows. Smith reports a form of this species with three series of indistinct dark spots, a vertebral and two lateral ones extending down the whole length of the back and tail. I have not seen this specimen.

Distribution: The species has been taken in the provinces of Narathiwat, Pattani, Phatthalung, Khon Kaen, and at Bangkok. Since the species is known also from India, Assam, Burma, Indo-

China, South China, Malaya and the Archipelago, it is probably present in the lowlands everywhere in Siam where suitable aquatic conditions exist.

Remarks: It is a fish-eater and for the most part a gentle snake. The number of teeth in the available specimens show this species to have several more than the 10-16 reported by Smith (1943).

Little is known of the effect of the poison of this species on man. D'Abrew writes * of the effects of a bite of this species: "The subject a healthy man of about 36, while attempting to catch the snake, which had previously been irritated, was bitten on the back of the right hand between the thumb and forefinger. There were two distinct punctures and the parts got inflamed at once though scarcely two drops of blood were shed. Fifteen minutes later the hand began to throb, and the throbbing lasted for about an hour, after which no ill-effects were felt. The snake was a little over a foot in length, the place of the occurrence was Parbatipur, Bengal."

A specimen, No. 36307 collected by Dr. Georg Heuser was kept alive. Eleven young, (Nos. 36303-36313) were born July 8, 1959. Their color and markings are very similar to those of the described specimen.

Enhydris smithi (Boulenger)

(Figs. 78, 78a)

Hypsirhina smithi Boulenger, Journ. Nat. Hist. Soc. Siam, vol. 1, 1914, p. 69 (type-locality, Bangkok).

Enhydris smithi; Smith, Journ. Nat. Hist. Soc. Siam, vol. 8, no. 1, Dec., 1929, p. 49; The fauna of British India, Ceylon and Burma including the whole of the Indo-Chinese subregion; Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 385-386.

Diagnosis: Scales in 21 rows; two or three postoculars one of which is the subocular; nasals broadly in contact; loreal touching internasal; temporals, 1 +2 +3(4); ventrals, 118-121; blackish with light cross-bars or annuli.

Description of species (from No. 676 Bangkok): Rostral more than twice as wide as high, sides parallel, well visible from above; nasals large, broadly in contact behind rostral; nostrils transversely lunate, connected by a suture to first labial; internasal single, twice as wide as long, touching loreal; prefrontals as large as or slightly smaller than nasals; frontal one-and-a-half times as long as wide, sides subparallel, not twice width of supraoculars, which are scarcely wider posteriorly than anteriorly; length of frontal equal to its distance from rostral, not or but slightly shorter than parietal;

* The Journal of the Bombay Natural History Society, vol. 22, 1913, p. 203.

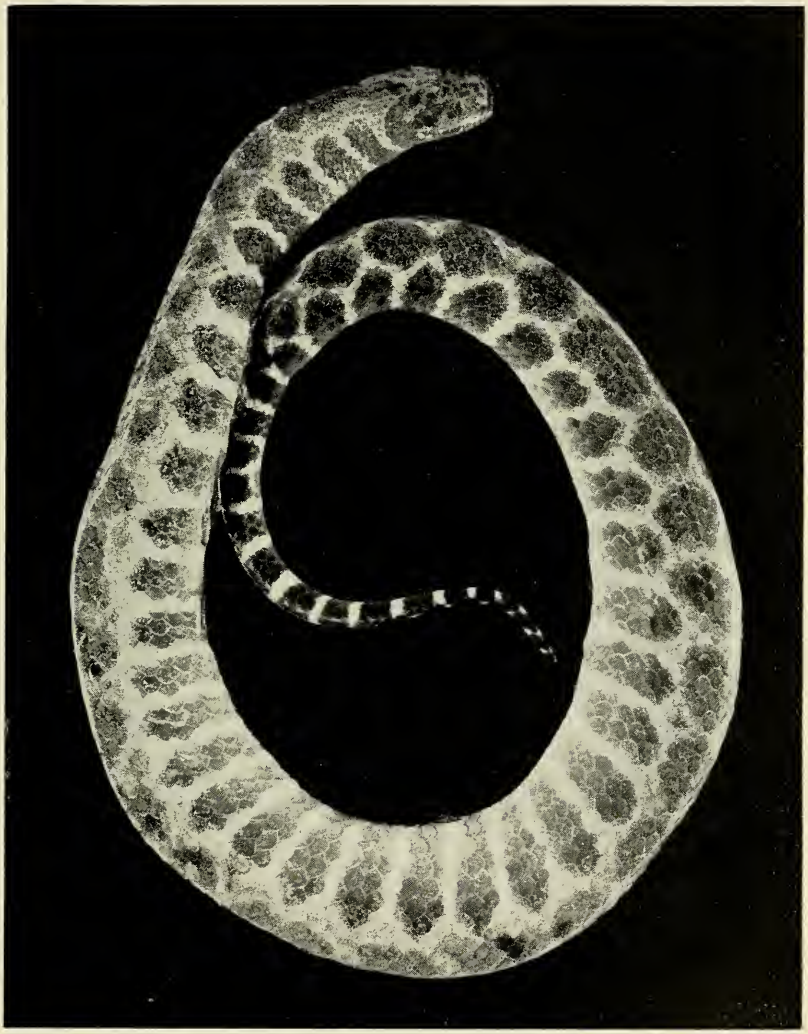

FIG. 78. *Enhydris smithi* (Boulenger). No. 678, Bangkok. Total length, 484 mm.; tail, 93 mm.

one (or two) loreals; a large preocular; two postoculars and a subocular; temporals, 1 + 2 + 4; eight supralabials, fourth touching eye, fifth and sixth touching subocular; mental very small; ten or eleven infralabials, five touching first pair of chinshields which are nearly three times size of second pair (latter separated posteriorly by two scales); seven scales intervene between second pair and first widened ventral.

Scales, smooth, distinctly larger posteriorly on body than anteriorly; the scalerow-formula: at first widened ventral, 35; at 10th, 25; middle of body, 21; before vent, 19. Ventrals, 121; subcaudals, 49; anals, 2; head small; greatest diameter of body about 26 mm.; tail suddenly diminishing in diameter behind vent. A more or less distinct ridge following mid-line of body.

Color in life: On middle of dorsum, a series of 32 dark rounded spots enclosed by a network of gray-lavender that sends down and across venter a series of 34 narrow lavender-gray bars, above, becoming yellowish white low on sides and across venter where they widen somewhat; a series of 34 distinct black lateral bands varying in width from two to five scale-lengths, rather pointed above, extending down and across venter, separated from median series by the gray-lavender ground color, and from each other by the narrow light lines. Tail with 14 black annuli separated by yellow-white narrower bands, the black ones widest posteriorly. Head with a black mark beginning on parietal, curving about jaw-angle and sending forward a branch towards eye; a black median stripe about one inch long on nape; remainder of head, including labials, flecked or clouded with black; a symmetrical dark figure on chin with four lighter areas touching it.

Measurements in mm.: Nos. 676, 677, and Type. Total length, 484, 486, 400; tail, 93, 96, 80; width of head, 15, 14, ?; length of head, 21, 20.8, ?.

Variation: The species is now known from six specimens most of which are females. The ventrals vary between 118 and 127, the subcaudals from 49 to 56.

A second Bangkok specimen in our collection, No. 677, differs considerably from the described specimen in having on the gray brown dorsal background about 42 dark transverse spots (as if two smaller spots were united on back and these sometimes connecting with an irregular line of indefinite dark spots some scarcely larger than a single scale). The characteristic head markings of *smithi* cannot be discerned, the black being scattered unsymmetrically on top and sides of head. There are two yellowish spots on first chin-shields.

The measurements of this male specimen is presented above. The ventrals number 118½, the subcaudals, 53. There are 30 scales on occiput, 23 on neck, 21 on the body, 19 before vent. The lateral black bars number 37, the annuli on tail 21. Both specimens are illustrated.

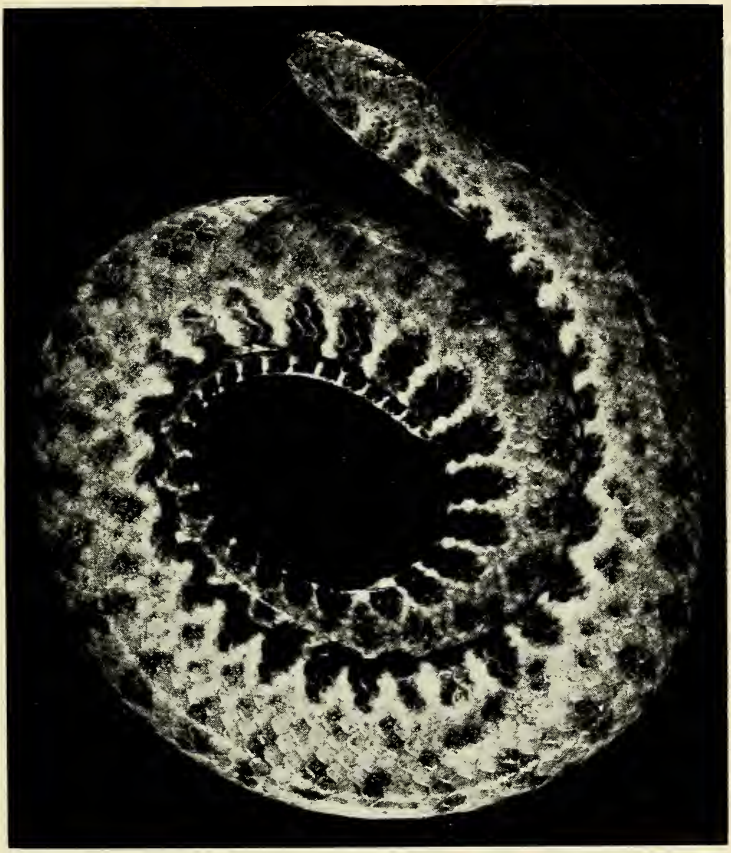

FIG. 78a. *Enhydris smithi* (Boulenger). No. 677, Bangkok (city), Thailand. About natural size.

Distribution: The species is known only from Prachuap Khiri Khan (Hua Hin) and the environs of Bangkok.

Enhydris jagori (Peters)

Hypsirhina (Eurostus) jagori Peters, Mon. Akad. Wiss. Berlin, 1863, p. 245 (type-locality, "Siam").

Hypsirhina jagori: Günther, Reptiles of British India, 1864, pp. 282-283; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, p. 1; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 6; Flower, Proc. Zool. Soc. London, 1899, p. 676.

Hypsirhina enhydris subtoeniata (sic.) Bourret, Bull. Gen. Inst. Pub. Hanoi, Mar. 1834, pp. 9-10 (type-locality Soc Trang, Cochin, China); Les Serpents de l'Indochine, 1936, p. 282 (also spelled *subtaeniata*).

Enhydris jagori: Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3. Serpentes, Dec. 1943, pp. 384-385.

Diagnosis: Scales in 21 rows; loreal in contact with the single internasal; frontal broader than supraocular; anterior chinshields as large or larger than second pair; a median darker stripe from occiput onto neck soon developing indefinite paired spots, approximately of the area of two scales; a row of lateral spots; first and third scalerows yellowish cream; second row buff salmon; a zigzag line borders ventrals on each side.

Description of species (from No. 34973, from near Udon Thani): Rostral angular, wider than high, visible above; nasals large forming a median suture, their anterior borders curving, the nostril pierced near center; suture runs from nostril to first labial; internasal undivided, much broader than long; prefrontal a little smaller than nasals; frontal about as long as its distance from tip of snout, not as long as parietals, wider than supraocular; loreal longer than high, touching three labials; a single preocular touching two supralabials; two postoculars; temporals, 1+2+3; a pair of scutes behind parietals somewhat enlarged; eight supralabials, the fourth entering orbit; diameter of eye slightly less than its distance from mouth; ten infralabials, first four in contact with first pair of chinshields, which are wider and as long (or nearly so) as second pair; latter separated by two pairs of scales.

Scales smooth, without pits; scale-formula: 33 (about occiput), 23, 21, 19 (before vent), the outer rows scarcely larger than others; ventrals, 146; anal, divided; subcaudals, 65.

Color in life: Above generally grayish brown; a median dark stripe begins on frontal, its edges not regular but covering three to four scalerows, continuing but growing somewhat darker posteriorly. On this develop paired or alternating spots the area of one or two scales; a dim dark stripe continues a short distance on neck, then tends to form small ocellate or "flowerlike" spots on fourth, fifth, and sixth scalerows, the spots separated from each other by a single transverse scalerow; supralabials yellowish cream, the color extending as a line to tail on third scalerow; second scalerow buff to salmon; first row similar to third; edge of ventrals with a grayish zigzag line on each side; a very indistinct series of dots along mid-line; subcaudals edged laterally with a darker gray zigzag line; throat with a dim lavender brown wash; a very indistinct lighter dorsolateral line along latter half of body.

Measurements in mm.: Total length, 418; tail, 87; width of head, 8.8; length of head, 17; greatest diameter of body, 15.

Remarks: The specimen was taken in a dried stream esconsed at the bottom of a footprint of a water buffalo. The specimen is young and is not particularly stout.

Malcolm Smith gives the variation in ventral count as 116 to 145; for subcaudals, 38 to 61.

Genus *Homalopsis* Kuhl and Van Hasselt

Homalopsis Kuhl and Van Hasselt, Alg. Konst. Lett. Bode, vol. 1, 7, 1822, p. 101; Isis 1822, p. 474 (type of genus *Coluber horridus* Daudin).

Diagnosis: Body cylindrical, head distinct from neck, scales small, striated and strongly keeled; ventrals wide; subcaudals paired; eye small with a vertically elliptical pupil. Head covered with large, usually normal, shields (only occasionally scales fragmented); nasals partly divided forming a median suture; internasal usually divided; a loreal present.

Maxillary teeth, 12-13 followed by a pair of rather small, grooved teeth; posterior maxillary teeth smaller than those on anterior part of maxillary.

Only a single species, *Homalopsis buccata,* is recognized in this genus, although several nominal species have been described from the Indian region all of which have been placed in synonymy. The species is widely distributed, being known from Burma throughout southeastern Asia, the Malay Peninsula and Archipelago.

The species is not rare in Thailand, being found commonly, even in the city of Bangkok, about klongs and ponds, fishing in the water or burrowed into mud along their edges.

Malcolm Smith, in the Journal of the Natural History Society of Siam, vol. 2, May 1917, p. 255-256, reports and figures a double-headed specimen. He states, "If my memory serves me rightly similar abnormalities in development have already been recorded twice for this same species."

In 1959 a photograph of a double-headed specimen appeared in a Bangkok newspaper. I later saw this specimen. It was being kept alive in captivity where it was reported as feeding well and keeping healthy. It would seem that the species has a propensity for producing double-headed monsters.

Homalopsis buccata (Linnaeus)

(Fig. 79, 80)

Coluber buccatus Linnaeus, Museum, S. R. M. Adolphi Friderici Regis, p. 29, pl. 19, fig. 3; Systema naturae, 10th Ed., 1758, p. 217 (type-locality, India).

Homalopsis buccata: Schlegel, Essai sur la physionomie des serpens, vol. 2, 1837, pl. 13, figs. 1-5; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 943; Günther, The reptiles of British India, 1864, pp. 285-286; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, p. 40; Boulenger, The fauna of British India . . . Reptiles and Batrachians, 1890, p. 374, fig. 109; Catalogue of the snakes in the British Museum . . . vol. 3, 1896, pp. 14-15; fig. 1, skull; Flower, Proc. Zool. Soc. London, 1899, pp. 677-679; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 162-163,

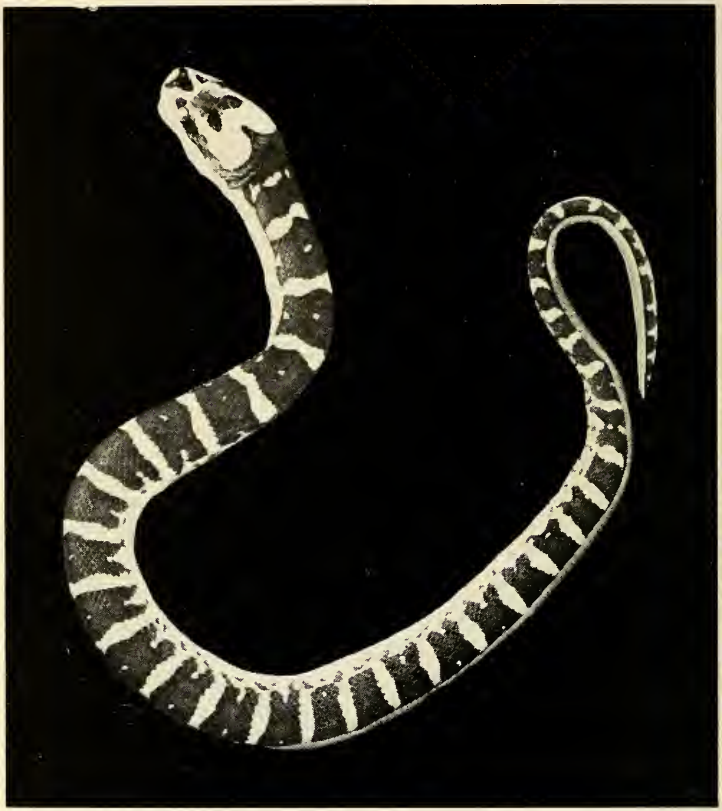

FIG. 79. *Homalopsis buccata* (Linnaeus). No. 3874 yg.♀, Na Pradoo, Pattani province, southern Thailand. Actual total length, 249 mm.; tail, 60 mm.

fig.; Wall, Journ. Bombay Soc. Nat. Hist., vol. 29, 1924, p. 867; *ibid.*, vol. 30, 1925, p. 817; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 1, 186-187, fig. 69; M. Smith, Journ. Nat. Hist. Soc. Siam., vol. 1, no. 1, Feb. 1914, p. 11; *ibid.*, no. 2, 1914, p. 101; *ibid.*, no. 3, Mar. 1915, pp. 187-213; *ibid.*, vol. 1, no. 4, p. 162 ("Bangnara, Patani"); The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943; pp. 390-392, fig. 123; Bourret, Les serpents de l'Indochine, vol. 2, 1936, pp. 293-294, fig. 117 (literature list); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38 pt. 2, 1958, pp. 1160-1161, fig. 32.

Coluber monolis Linnaeus, Systema Naturae, 10th Ed. 1758, p. 220 (type-locality, "America" (*ex errore*).

Coluber subalbidis Gmelin, Systema Naturae, 1788, p. 1103 (based on Seba, vol. 2, pl. 21, fig. 3).

Coluber horridus: Daudin, Histoire naturelle des reptiles, vol. VII, 1803, p. 71 (based on Seba's Serpent d'Amerique).

Homalopsis hardwickii Gray, Zoological miscellany 1842, p. 65 (type-locality, India).

Homalopsis semizonata Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1855, p. 187 (type-locality, Martaban, Calcutta).

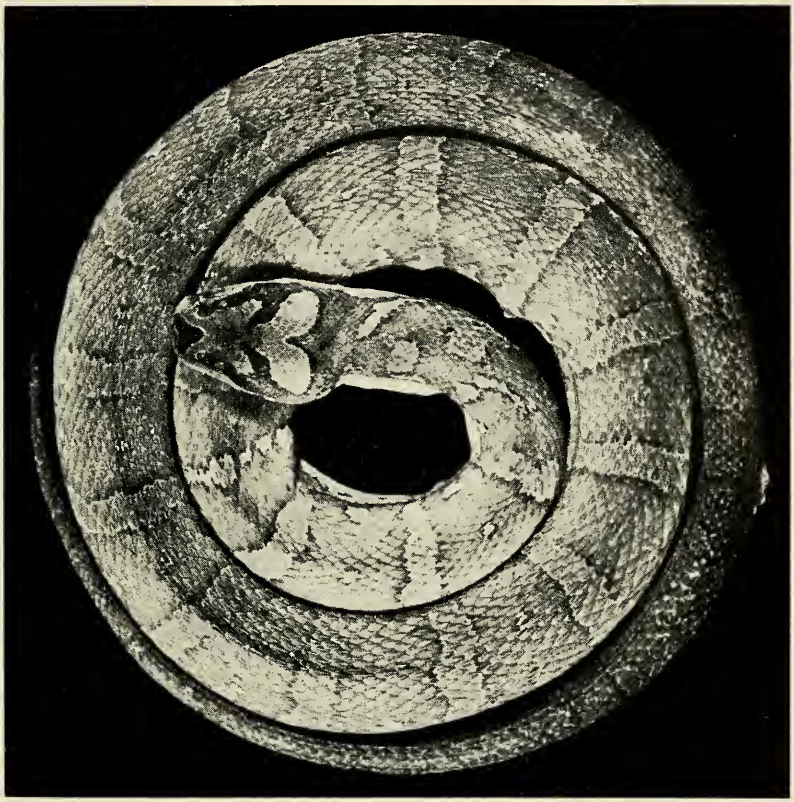

FIG. 80. *Homalopsis buccata* (Linnaeus). No. 34485, Pattani, Pattani province, southern Thailand. Actual total length, 944 mm.; tail, 230 mm.

Diagnosis: Generic characters. Frontal often broken, often narrower than supraocular; one or two loreals; one to three suboculars, separating labials from eyes; chinshields in a transverse row; number of scalerows variable, 37-47; labials often broken transversely.

Description of species (from No. 34485, Pattani): Snout broadly rounded anteriorly. Rostral considerably wider than high, narrowly visible above; a pair of large, partially divided nasals, broadly in contact mesially; nostrils lunate, dorsal; a pair of very small subtriangular internasals; prefrontals three to four times as large in area as internasals, in contact laterally with nasal, loreal, and preocular; frontal slightly wider but distinctly longer than supraoculars, broken transversely (abnormally) into two parts, shorter than its distance from tip of snout, considerably longer than parietals; loreal elongate, twice as long as wide touching three

supralabials, a nasal, and a preocular; one or two preoculars, three or four suboculars, two postoculars; temporals, 2+4+6, 2+3+6; supralabials, 13-13, the first seven or eight vertically elongate, last ones smaller, shorter. Mental small triangular; a pair of elongate infralabials in contact behind mental; only a single elongate pair of chinshields, in contact with three or four infralabials, and an elongate scale on outer border of each shield; 17 or 18 infralabials, last six very small.

Scale-row formula: 50 (occiput), 41, 39, 27, scales striated and keeled except one to three outer rows. Keels tuberculate or knob-like on sides above vent. Ventrals, 165; subcaudals, 88, divided; anal scale, divided; ventrals and subcaudals longitudinally striate. Eye small, its diameter about equal to its distance from mouth.

Color: Young: brownish black above with 27 narrow ivory-white transverse bands around body, dividing dorsal color into 28 large blotches each partly or completely divided by a very narrow light ring or a few white spots; 17 major light bands and a similar number of very narrow (or dotted) transverse lines between them; a broad chevron on occiput, nearly divided mesially, some lighter areas above and behind eye; a V-shaped white mark on snout; supralabials and three or four outer scalerows, except first, ivory; chin, lower lips, and venter ivory with black dots on outer edges of ventrals; subcaudal region blackish; a black band across anal scale.

Adults: The light bands are gray-brown edged with dark brown; dorsal blotches an intermediate brown. The row of ventrolateral spots partly on ventrals, partly on outer scalerow. Subcaudal area mottled ivory and dark brown. Markings on head largely dark brown.

Measurements in mm.: Total length, 944; tail, 230; width of head, 26.5; length of head, 33.

Variation: The suture partially dividing the nasal runs from the nostril to the first labial. The internasal in some populations is a single scale, while occasionally the prefrontals may be separated by an azygous scale. Fragmentation of the frontal is usually in the posterior part. The loreal may be divided into two parts, and is never in contact with the internasal. Most of the posterior supralabial scales bordering the lip are really only the lower parts of divided supralabials, the upper parts being regarded as temporals.

Malcolm Smith records the variation in ventral-subcaudal counts as follows: 160 to 170 ventrals for males and females; subcaudals, males, 78-103; for females, 70-91. Variation in scalerows at the middle of the body is 43 to 47, the usual number being 45.

Distribution: In Thailand the species occurs widely about the mouths of rivers, usually in areas affected by tides and tidal waters. It is not uncommon near Bangkok. Elsewhere the species is known in similar situations in southern Burma, Cambodia, Malaya, and the Indo-Australian Archipelago.

Genus *Cerberus* Cuvier

Cerberus Cuvier, Règne animal, 2nd Ed., vol. 2, p. 81, (type, *Coluber cerberus*).

Hurria Daudin, Mag. Encyclop. vol. 5, An. 8, (1802), p. 434 (type, H. *schneideriana* = *cerberus*).

Diagnosis: Body more or less cylindrical, scales strongly keeled, and with longitudinal striations; scales in 21-27 rows, reducing to 17 before vent; nasals in contact; two internasals, two prefrontals; frontal small; supraoculars relatively large; parietals broken into small scales; two loreals; one preocular, one postocular; two suboculars separating labials from eye; eleven supralabials; ventrals widened, 12-17 maxillary teeth, the last two enlarged, grooved.

A single species is known.

Cerberus rhynchops (Schneider)

(Fig. 81)

Hydrus rhynchops Schneider, Historia Amphibiorum . . . vol. 1, 1799, p. 246 (Based on Russell's Indian Serpents, pl. 17 [*Hydrus cinereus* (1802) of Shaw, and *Coluber cerberus* Daudin (1803) are based on the same plate]).

Homalopsis rhynchops: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 941.

Cerberus rhynchops: Günther, Reptiles of British India, 1864, p. 279; Anderson, Proc. Zool. Soc. London, 1876, p. 179; Murray, Zool. Sind., 1884, p. 381; Tirant, Notes sur les reptiles et les batraciens de l'Indochine et du Cambodge, 1885, p. 40; Boulenger, The fauna of British India, Ceylon, and Burma; Reptilia and Batrachia, 1890, pp. 374-375; Catalogue of the snakes of the British Museum, 2nd Ed., vol. 3, 1896, pp. 16-18, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia; 1912, pp. 163-164; Wall and Evans, Journ. Bombay Soc. Nat. Hist., 1900, pp. 345, 612; Alcock and Rogers, Proc. Roy. Soc. London, 1902, p. 449; Annandale, Journ. Asiat. Soc. Bengal, 1905, p. 176; Mem. Ind. Mus., vol. 5, 1915, p. 170; Wall, Journ. Bombay Nat. Hist. Soc., vol. 16, 1905, p. 307; *ibid.*, vol. 26, 1919, p. 89, pl—; Wall, Ophidia Taprobanica or the snakes of Ceylon, 1921, pp. 257-262; Bourret, Les serpents de l'Indo-chine, vol. 2, 1936, p. 295; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, No. 2, 1914, p. 102; *ibid.*, no. 3, p. 213; M. Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 393-394 (synonymy).

Hurria rhynchops: Wall, Journ. Bombay Nat. Hist. Soc., vol. 29, 1924, p. 867; Prater, *ibid.*, vol. 30, 1924, p. 171; Stejneger, Herpetology of Japan, 1907, p. 304.

Diagnosis: Characters of genus. Scales in 23-25 rows; a suture from nostril to first labial; frontal small.

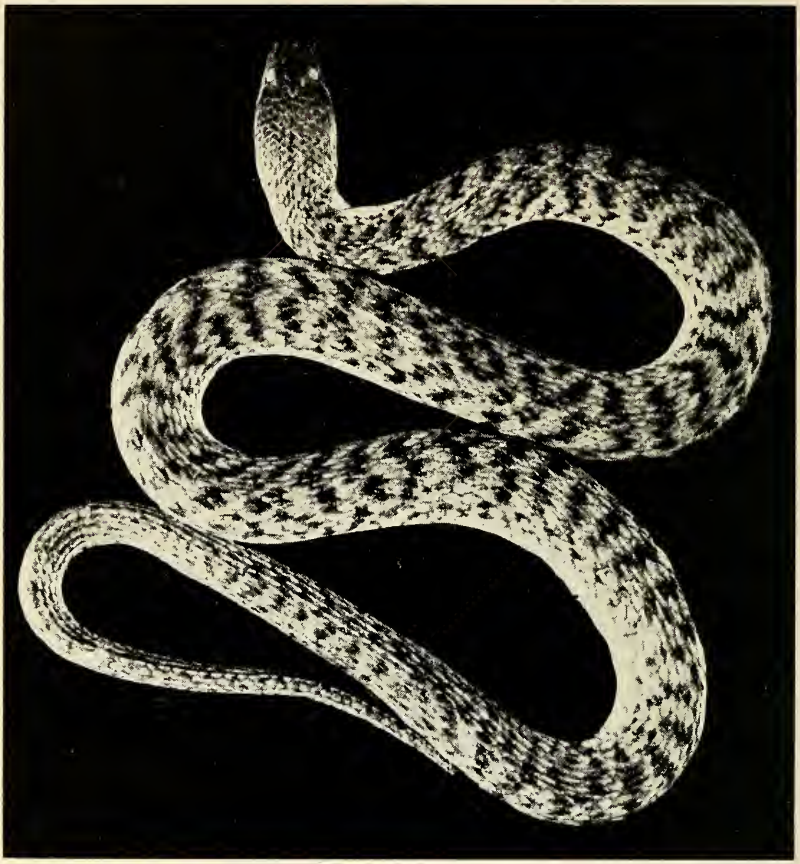

FIG. 81. *Cerberus rhynchops* (Schneider). No. 33521, Ang Hin, Chon Buri province, southeastern Thailand. Actual total length, 470 mm.; tail, 85 mm.

Description of species (from No. 33521, Ang Hin, Chon Buri): Rostral with parallel sides, as high or slightly higher than wide; nasals large, in contact behind rostral; nostrils transverse and lunate, with valves; a suture from nostril to first labial; internasal divided into two triangular moieties, in contact laterally with two loreals; a pair of preoculars, unequal, longer than wide; frontal triangular, symmetrical, small (may represent only a portion of the scale); parietals broken up into scales similar to occipital scales; two loreals, the lower largest; one preocular, one postocular; two suboculars touching one another below eye, separating labials from orbit; two large anterior temporals, (the upper may represent a portion of parietal), three secondary and three tertiary temporals;

eleven supralabials, line of the mouth turning up suddenly behind eighth, fifth and sixth below eye, all relatively high; eleven infralabials, four bordering first pair of chinshields, which are likewise bordered by a scale nearly as long as chinshield itself; second pair of chinshields small and separated by paired scales; eight or nine scales between first chinshields and first ventral.

Scalerow-formula: 27 (occiput), 25, 25, 17, scales striate with a strong keel. Ventrals, 148; subcaudals, 56+; anals, 2.

Color in life: Above, dorsum largely olivaceous gray with a series of about 65 indefinite black crossbars; three outer scalerows ivory or yellowish, with occasional black flecks on first and third rows; ventrals olive-gray with considerable yellow on outer parts of ventrals; subcaudal area grayish black becoming denser towards tip; labials yellow-ivory, most scales with a black spot. Chin flecked with dark pigment; more or less distinct black line from side of snout through eye extending back on side of neck for some distance.

Measurements in mm.: Total length, 470; tail, 85; width of head, 13.8; length of head, 21.

Variation: Considerable variation obtains in various populations of this species—variations that have to do with the degree of development of the frontal, the presence of one or two loreals, the relative size of the temporal scales, and the number of the ventrals and subcaudals. It is not certain that any of these variants require nomenclatorial designation.

Distribution: The species is coastal and is to be found on all Thai coasts. It is common in the soft mud in mangrove areas. In the fishing village of Yahling near Pattani, the snakes were found at night on the edge of the shore especially about houses built at the edge of the sea. At Ang Hin they could be found in mud under the houses.

Outside of Thailand the species is widespread. It is known in India, Burma, Ceylon, Malay peninsula and the Indo-Australian Archipelago.

Remarks: The species may reach a length of one meter. Malcolm Smith (1943) states that it is common about the mouths of rivers, and has been taken in fresh water 100 miles from the sea.

Genus *Bitia* Gray

Bitia Gray, Zoological miscellany, 1842, p. 64 (type of genus, *Bitia hydroides*).
Hipistes Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 77 (type, *fasciatus*).

Diagnosis: Body generally cylindrical, with smooth scales, in 37 to 43 rows; ventrals narrow, about half width of body, keeled laterally; eye small, with vertical or elliptic pupil, directed upwards; head, posterior to frontal largely covered with small undifferentiated scales; labials elevated, separated from eye; nasal divided. Eleven to 13 maxillary teeth followed by two slightly enlarged grooved teeth.

The genus is known to have a single species. It has been reported from Bangkok by Boulenger (1896) on the basis of a specimen received from the "Christiania Museum." The species has not been found by Malcolm Smith or by myself. It is not impossible that the Bangkok record is in error since no other specimen has been taken anywhere in Thailand.

Bitia hydroides Gray

Bitia hydroides Gray, Zoological miscellany, 1842, p. 64; Catalogue of the snakes in the collection of the British Museum, 1849, pp. 63, 78 (type-locality unknown).

Homalopsis hydrina Cantor, Journ. Asiat. Soc. Bengal, vol. 16, pt. 2, 1847, p. 951, pl. 40, fig. 4 (type-locality, Kedah Coast, Malaya). (p. 104 in reprint.)

Hypistes hydrinus: Günther, The reptiles of British India, 1864, p. 287, pl. 24, fig. H; Stoliczka, Journ. Asiat. Soc. Bengal, vol. 29, 1870, p. 207; Anderson, Proc. Zool. Soc. London, 1871, p. 181; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 381-382, fig. 112; Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 24; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 166; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 400; Journ. Nat. Hist. Soc. Siam, vol. 1, no. 2, Aug., 1914, p. 103; *ibid.*, vol. 1, no. 3, Mar., 1915, p. 214; Tweedie, The snakes of Malaya, 1954, p. 89.

Diagnosis: Characters of the genus. A single internasal separating nasals; a loreal present; scales juxtaposed or subimbricate, in 35-43 rows; tail short, feebly compressed, a subocular present. Ventrals narrow with two keels; nasals divided; parietals broken up.

Description of species: Rostral broader than high, slightly visible from above; internasal single, the scale completely separating nasals; prefrontals forming a median suture, touching loreal, preocular, and supraocular laterally; frontal wider than supraoculars, longer than its distance from tip of snout, somewhat narrowed in middle; parietals broken into small scales not differentiated from those on occiput; nasal completely divided (usually), nostril a narrow slit; loreal rather large touching three labials; preocular and subocular subequal, in contact; suborbital scale prevents labials from entering orbit; postocular small; two anterior temporals; supralabials seven, fourth below eye, fifth and sixth largest, highest;

eyes on top of head directed upwards; ten or eleven infralabials, last five touching anterior chinshields; three posterior pairs of chinshields small; dorsal scales smooth, elongate, usually with a small expanse of skin showing between scales. Scales in 35-43 rows, each scale with two keels; keeled subcaudals, 21-35; anals, 2.

Color: Pale gray above with black cross-bands as broad as interspaces (or a little narrower). Head gray, nearly uniform; outer row of scales white; venter and subcaudal region white. In life, yellow, barred with black, the belly buff.

Measurements in mm.: Total length, 450; tail, 35.

Remarks: The species is presumably rare in Thailand. Whether the Bangkok record is trustworthy may be questioned. However its occurrence in Burma, and in northern Malaya make its presence in the southern part of Thailand almost a certainty.

Genus *Gerarda* Gray

Gerarda Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 77 (type of genus, *Gerarda bicolor*).

Campylodon (not of Cuvier) Duméril, Mem. Acad. Sci. France, vol. 23, p. 499; Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, pp. 963-964 (type of genus, *C. prevostianum*).

Diagnosis: Small snakes, rather cylindrical in form; eye reduced, with vertical pupil; head slightly distinct from neck, with large shields; nasals separated by a single internasal. Scales in 17 rows, reducing to 13 in latter part of body; ventrals widened, subcaudals double. Maxillary elongated beyond palatine, with 11 to 13 teeth, followed after a short diastema by two grooved poison-fangs; 24 to 25 teeth on dentary, subequal.

Only a single species known in the genus.

Gerarda prevostiana (Eydoux and Gervais)

(Fig. 82)

Coluber (*Homalopsis*) *prevostianus* Eydoux and Gervais, Guerin, Mag. Zool. Cl., vol. 3, 1837, p. 5, colored pl. 15 (type-locality, "Manila").

Gerardia prevostiana: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 379; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 20-21; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 616; Wall, *ibid.*, vol. 16, 1905, p. 307; Kloss, Journ. Federated Malay States Mus., vol. 10, 1921, p. 201; Wall, Ophidia Taprobanica, or the snakes of Ceylon, 1921, pp. 262-265, fig. 53; Journ. Bombay Nat. Hist. Soc., vol. 19, 1924, p. 868; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 62; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 171.

Gerarda bicolor Gray, Catalogue of the snakes in the collection of the British Museum, 1894, p. 77 (type-locality, stated erroneously "West Indies." Suggested by Theobald that this is an error for "East Indies"); Günther, Ann. Mag. Nat. Hist., ser. 4, vol. 1, 1868, p. 421; Theobald, Journ. Linn. Soc. Zool., vol. 10, no. 41, 1868, p. 58; Theobald, Descriptive catalogue of the reptiles of British India, 1876, p. 180.

Heleophis flavescens Müller, Verh. Nat. Ges. Basel, vol. 7, 189[illegible], p. 286, pl. 5, fig. 2 (type-locality, East Indies).

Diagnosis: A species having frontal two-and-a-half times width of supraocular; sides of frontal subparallel, front nearly a straight line; single internasal wider than nasal, constricted near middle, extending a little farther forward than nasals; preocular touching frontal (or not); eight supralabials, fourth entering orbit; second pair of chinshields small, separating a pair of scales; anal divided; first subcaudal single, others divided.

Description of species (from No. 33557 Ang Hin, Chon Buri): Rostral more than twice as wide as high, narrowly visible above, its posterior border with a median concave indentation; nasal scale subround, nostril a transverse lunate slit; internasal slightly wider than nasal, somewhat constricted in middle, its anterior end convex; prefrontals rather large, separated from eye, a little wider than long, touching loreal and preocular, in contact or not with supraocular; frontal ($3 \times 3\frac{1}{2}$ mm.) five-sided, the sides and front forming nearly straight lines, much shorter than its distance to tip of snout, shorter than parietals; supraoculars less than half width of frontal; loreal about as high as long, touching three first labials; preocular, touching only one supralabial, reaching top of head, touching or separated narrowly from frontal; two postoculars, lower passing partly under eye; a single temporal touches both postoculars; lower anterior temporal pushed back by contact between upper temporal and sixth labial; temporal formula: $2 + 2 + 3$ (on one side somewhat irregular); eight supralabials, fourth bordering orbit, seventh definitely largest, eighth smallest; seven infralabials, first four touching first chinshields, which are four times size of second pair.

Scalerow-formula: 22 (occiput), 17, 17, 13, scales smooth and subequal. Ventrals, 145; subcaudals, 34; anal, divided.

Color in life: Nearly uniform gray-olive above; three outer scalerows yellow-ivory, the scales often showing a slight edging of olive. Venter gray, each ventral scale with some ivory or gray-ivory on ends, and this may continue across back edge of scale; subcaudals nearly uniform dark gray below with small transverse areas of ivory; supralabials ivory with olive sutures; chin, throat, and sides of neck yellowish; skin between scales grayish.

Measurements in mm.: Total length, 346; tail, 48; width of head, 9; length of head, 13.

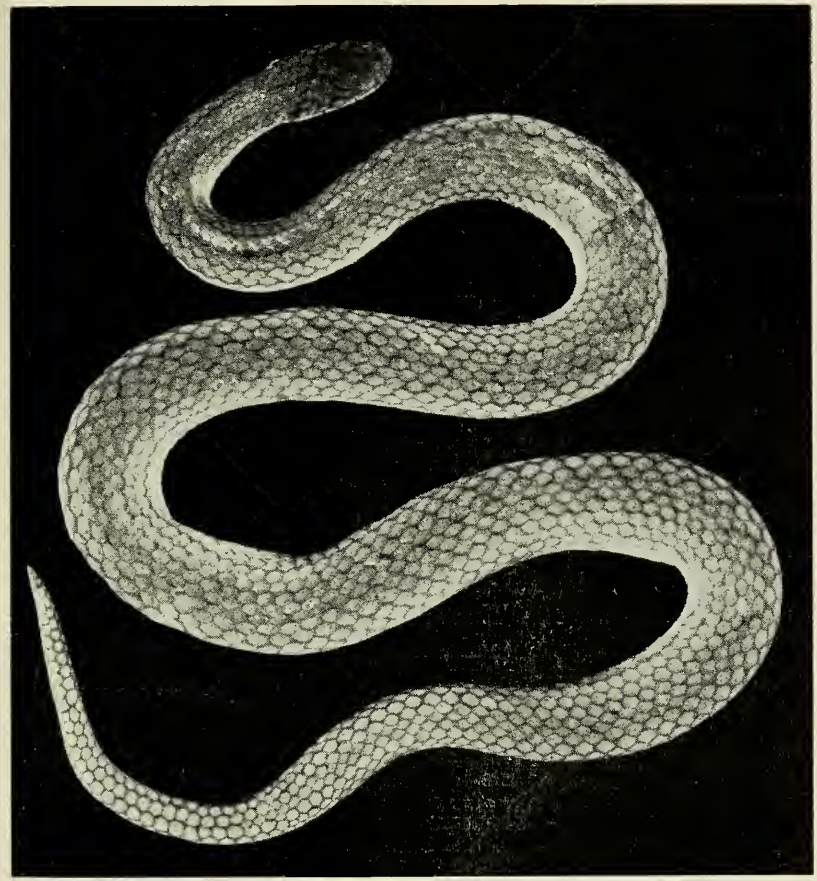

FIG. 82. *Gerarda prevostiana* Eydoux and Gervais. No. 33559, Ang Hin, Chon Buri, Thailand. Actual total length, 458 mm.; tail, 38 mm.

Variation: There are certain differences in the dorsal head scutes of Thai specimens when compared with descriptions and figures of specimens from elsewhere. Unfortunately I have no material from the western or eastern part of the range for comparison.

Distribution: This is presumably the first record of the species from Thailand. It was discovered in mangrove swamps at Ang Hin, where it appeared to be rather common. Fifteen specimens were collected and more might have been taken.

Outside of Thailand the species occurs in Ceylon, the coast of India, Burma and Perak. It will doubtless be found to occur on the western coast of Thailand, if suitable localities exist there.

Genus *Erpeton* Lacépède

Erpeton Lacépède, Bull. Sc. Soc. Philos. Paris, vol. 2, 1800, no. 46, p. 169 (type of genus, *tentaculatum*); Ann. Mus. d'Hist. Nat., vol. 2, 1803, p. 280; Gray, Catalogue of the specimens of snakes in the collection of the British Museum, 1849, p. 62. Duméril, Bibron, and Duméril, Erpétologie générale, vol. 7, 1854, p. 983; M. Smith, Bull Raffles Mus., no. 3, 1930, p. 63.

Rhinopirus Merrem, Tentamen systematis amphibiorum, 1820, p. 81.

Herpeton Wagler, Natürliches system der amphibien, 1830, p. 169; Günther, Proc. Zool. Soc. London, 1860, p. 115; The reptiles of British India, 1864, p. 228; Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, p. 25; M. Smith, The fauna of British India, Ceylon and Burma, Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 400-401.

Diagnosis: Body somewhat depressed covered with keeled scales; head distinct from neck, covered with large regular scutes but with some small scales intercalated and with two scaled tentaclelike processes growing from rostrum; ventrals very narrow, each with two keels; rostral scute separated from nasals by small scales; subcaudal scales not well differentiated. Maxillary teeth, 12-14, followed by two grooved teeth, not or scarcely larger than posterior maxillary teeth.

This genus has been known from a single species that has a relatively small range in Thailand, Cambodia, and Cochin China. It is aquatic, living in ponds, klongs, and slow-moving streams. A second form is described herein. The use of the tentaclelike processes is unknown; they seemingly cannot be moved by the snake, but respond to movements of the water about them. Malcolm Smith (1943) suggests that they might serve as "bait" for the fishes on which the serpent feeds.

Erpeton tentaculatum Lacépède

(Fig. 83)

Erpeton tentaculatum Lacépède, Bull. Sci. Soc. Phil. Paris, vol. 2, no. 46, 1800, p. 169; Ann. Mus. Nat. Hist. Paris, ser. 10, vol. 2, 1803, p. 284, pl. 50 (type-locality not given); Daudin, Histoire naturelle générale et particulière des reptiles, vol. 7, 1803, pp. 246-253, pl. 86.

Herpeton tentaculatum: Günther, Proc. Zool. Soc. London, 1860, p. 114, color plate, 23; Morice, Ann. Sci. Nat. Paris, ser. 6, vol. 2, 1870, pl. 20; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 42-43; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 25-26; M. Smith, Journ. Nat. Hist. Soc. Siam. vol. 1, no. 2, Aug., 1914, pp. 103-104, and 126-127, pl., fig. (photo of head), (Thai name *ngu kradang*); *ibid.*, vol. 1, no. 3, Mar., 1915, p. 187, and 214; Annandale, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec., 1916, pp. 91, 94; Gyldenstolpe, Küngl. Vet. Akad. Stockholm, vol. 55, 1916, p. 19; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 63; Bourret, Les serpents de l'Indochine, 1936, p. 305, fig.; M. Smith, The fauna of British India . . . vol. 3, serpentes, 1943, pp. 401-402, fig. 130, a., b., c. (*part.*).

Homalopsis herpeton Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 359; Abbildungen . . . 1839, p. 50, pl. 16.

Rhinopirus erpeton: Merrem, Tentamen systematis amphibiorum, 1820, p. 82.

Diagnosis: See generic characters above.

FIG. 83. *Erpeton tentaculatum* Lacépède. EHT-HMS No. 280, environs of Bangkok. Actual total length, 445 mm.; tail, 136 mm.

Description of species (from No. 280): Rostral not twice as wide as high, sides not parallel, notched mesially posteriorly; a median hexagonal postrostral scale flanked by one or more series of small scales completely separating rostral from enlarged nasals; latter scales form a median suture posteriorly, anteriorly partly separated by one small scale; nostril with a valve; nasal partially divided by a suture directed outward and somewhat downward; internasal divided into two equal parts, followed by a third scale touching a loreal; prefrontals about size of nasals, forming a median suture, separated from supraoculars; frontal small, separated from supraoculars by a row of scales (or touching it at a point on right side),

shorter than it its distance to rostral, shorter than parietals; parietals form a median suture, border frontal, but touch supraoculars only at a point; from near sides of rostral two tentaclelike processes grow out, covered by ten or eleven rows of scales; seven or eight scalerows around tentacle, the number in a row diminishing distally; 14 supralabials, none bordering orbit; these bordered above by a row of similar scales, three or four of which border eye; a rather large preocular preceded by two or three scales (that might be regarded as loreals) and 16 to 18 smaller scales; three postoculars; these followed by one larger temporal but scales following not differentiated from body scales; twenty infralabials, posterior ones somewhat elongated; first labials do not touch behind small mental; two or three pairs of chinshields, none touching labials. Body scales strongly keeled.

Scale-formula: 50 (across occiput), 36, 32, 26. Ventrals, approximately 116, about twice as large as adjoining scales, first separated from chinshields by 22 scales; subcaudals, 98, paired, but not very clearly differentiated; anal, undivided.

Color: Above light reddish brown; neck with paired spots that tend soon to join and form two narrow blackish lines a little more than one scale wide, separated by five scalerows which are gray becoming darker posteriorly; on tail these break up into a line of small elongate spots; laterally a broader dark-brown stripe, below which is a second similar line two scales wide, dim on neck but extending onto tail and there breaking into spots; venter yellowish with two rows of irregular broken dark spots of flecks extending nearly to tail; an indistinct darker mark extending on to head from neck. Anterior part of venter with slight paired darker spots.

Measurements in mm.: Total length, 445; tail, 136; width of head, 11.6; length of head, 17; width of body, 18; length of tentacle, 5; eye from tip of snout, 6.

Variation: The number of scalerows varies from 35 to 39; the variation in ventrals for males is from 103 to 122; for females, 114 to 116.

Distribution: In Thailand the species is known from Nakhon Si Thammarat (sea of Singgora) and at Bangkok. M. Smith states "Central and peninsular Siam." It occurs also in Cambodia and Cochinchina.

Malcolm Smith states (1943): "It is not uncommon in ponds and sluggish waters in the country around Bangkok if one knows where to look for it, . . ."

Remarks: The species of this genus are unique among the so-called fresh-water snakes in having greatly reduced ventral scales and the tentacular appendages on the snout. In part of the body, one ventral corresponds to one diagonally transverse row of scales. Farther back there may be one row and part of another and later two rows for each ventral scale; the subcaudals are divided. There are two large anals bordered anteriorly by three smaller scales.

Erpeton sp?

(Fig. 84)

In the collection there is a specimen, No. 34150, that differs considerably from the form just described. The differences have to do with color and markings, a larger number of ventrals, some head-scale differences, and the characteristics of the anal region. It was captured at Bangkok. I append a detailed description of the specimen, in the hope that others of the form may be recognized. A figure is given.

Description of type: Rostral more than twice as wide as high, notched below on labial border, excavated on front face, broadly bilobate above; followed behind by a postrostral, which is flanked on either side by a group of six or seven tiny scales separating rostral from the large nasals; latter form a median suture for about half their length, and are partly severed by a suture running laterally from nostril to edge of scale; nasals followed by a small pair of scales, which with a typical pair of prefrontals enclose a small azygous scale; frontal about one-fourth longer than wide, shorter than its distance from tip of snout, shorter than parietals; supraoculars about half width of frontal separated from frontal by a row of small scales; canthus rather distinct; preceding supraocular a scale half its size; a large preocular preceded by a scale nearly as large; eight or nine small scales bordering canthus above; 15-16 supralabials, three enlarged suboculars, three postoculars; 19 to 20 small scales in loreal area; "tentacles" not as long as distance between eye and tentacle; temporal scales small, about seven rows between labials and parietals; twenty infralabials, posterior ones elongate; chinshields not typical, a series of four more or less elongate scales on each side of groove.

Scale-formula: 47, occiput; 41, neck; 39, middle of body; 29, preceding vent, all scales strongly keeled. Scales of occiput and neck small, less than half-, often one-third size of scales around middle of body; vent bordered by a transverse anal, preceded by a pair of overlapping scales. Ventral scales, 125 beginning 28 (trans-

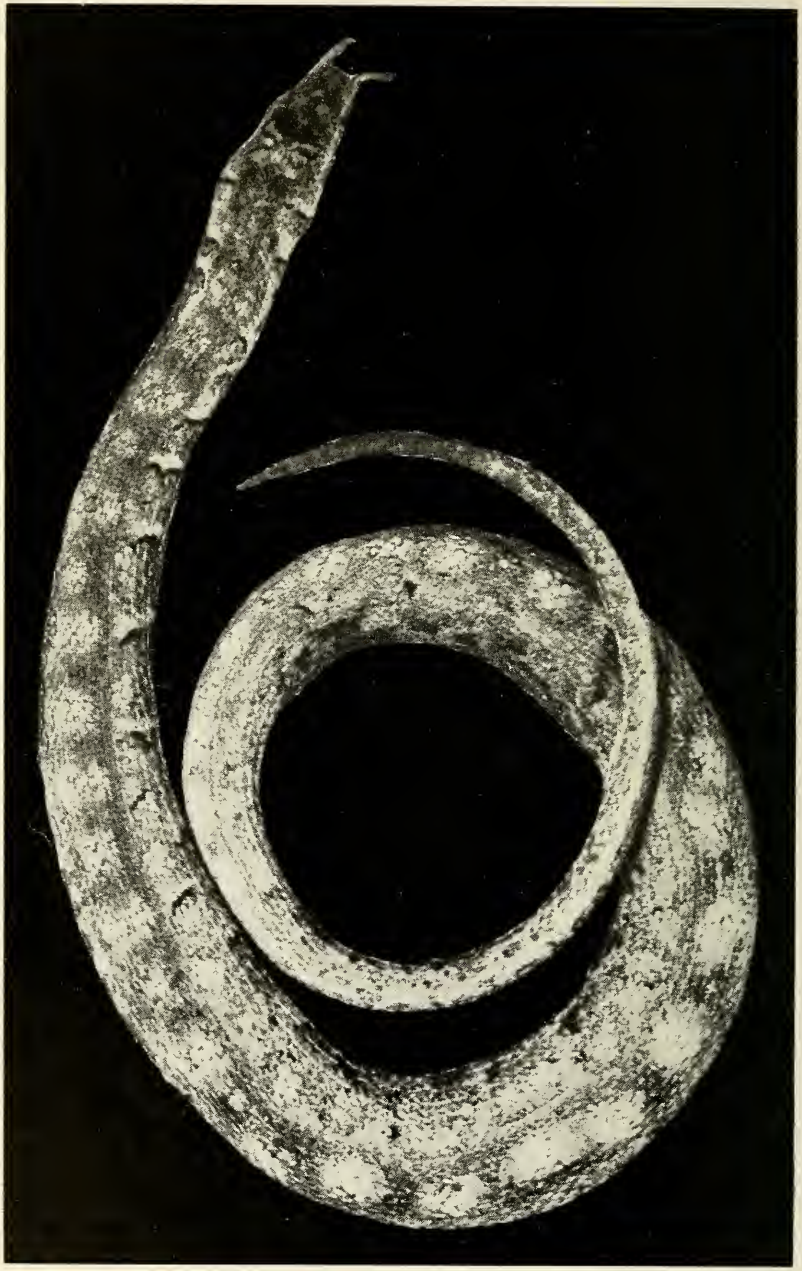

FIG. 84. *Erpeton sp.* No. 34150, from near Bangkok. Actual total length, 392 mm.

verse) scalerows behind mental, but number of transverse rows of scales from first ventral to vent is 141; and transverse rows preceding first widened ventral are 28 to back of head (jaw-angle).

Color: On dorsum and sides of body, generally variegated and mottled lavender-brown without evidence of longitudinal stripes. Top of head blackish brown mottled with indefinite lighter spots; a deep-black lateral stripe covers rostral and entire side of head to behind angle of mouth connecting with a black area covering lower jaw and chin; narrow light lavender lines edged with black, begin on sides of occiput, passing under neck but interrupted mesially below; a postparietal; lighter area edged with black; an ocellated spot below angle of mouth and a pair of similar spots on each side of the mental; on neck and sides of body anteriorly, a series of cream black-edged bars, occasionally touching on venter, becoming indistinct and lost posteriorly. A median series of rather large indefinite gray-lavender spots with a still more indefinite lateral series (see fig.); venter dull blackish generally; indefinite markings on tail; subcaudal area dark, similar to venter.

Measurements in mm.: Total length, 394; tail, 120; width of head, 10; length of head, 17; "tentacle," 4.2.

Remarks: The usual expectation in Colubrid snakes is the presence of one vertebrae to each ventral, and one transverse scalerow for each ventral. This is obviously not the case in this species.

Whether all the cephalic structural characters listed as distinguishing *tentaculatum* from this form are constant, only a study of more specimens of the two forms can tell. They are however easily separated by the anal scales and the color pattern.

Family Elapidae Boie

Elapidae Boie, Isis, 1827, p. 510.

Diagnosis: Grooved poison-fangs at front end of maxillary bone, usually followed by one or more solid teeth; loreal invariably absent. Pupil of eye round. Hypapophyses developed throughout vertebral column. Grooves may be present in certain of the other maxillary teeth.

This family of serpents is distributed in both hemispheres. In proportion to the other terrestrial snakes, Australia has the largest number of the Elapidae.

All members of this group have poisons that are dangerous to man and larger animals, and often lethal; however, many forms are small and the small quantity of venom they are capable of injecting is probably insufficient to be deadly to an adult human

being. Fortunately a number of the larger species are unagressive and seem to be reluctant to bite when handled or even when treated roughly.

Entering Thailand are five genera of Elapidae that may be differentiated by the following key:

KEY TO THAI GENERA OF THE ELAPIDAE

1. Very large snakes (to 5.5 meters in length) a pair of large postparietal shields; poison-gland on side of head, poison-fangs followed usually by three solid maxillary teeth; 15 scalerows at mid-body..... *Dendraspis*
   Rather large (to nearly two meters), medium, or small snakes lacking enlarged postparietal shields..... 2
2. Medium to small snakes with poison-glands much elongated pushing back into the body-cavity..... *Maticora*
   Poison-glands confined to head..... 3
3. Maxillary bone not extending forward beyond the palatine; vertebral series of scales enlarged in all Thai forms..... *Bungarus*
   Maxillary bone not extending forward beyond the palatine; vertebral series of scales not enlarged..... 4
4. Small snakes, scales in 13 to 15 rows; no elongated nuchal ribs permitting the nuchal skin to be stretched into a "hood". Transverse rows of scales not arranged obliquely..... *Calliophis*
   Medium snakes with elongated nuchal ribs permitting the nuchal skin to be spread into a "hood". Transverse scalerows obliquely arranged... *Naja*

Genus *Bungarus* Daudin

Bungarus Daudin, Mag. Encycl., vol. 5, year 8(1803), March, p. 434 (Based on Russell's Indian Serp., vol. 1, 1796, p. 3, pl. 3; Histoire naturelle . . . des reptiles, vol. 5, 1803, pp. 263-264, (type of genus, *fasciatus*).

Diagnosis: Head not differentiated from neck; maxillary bone not reaching beyond palatine; poison-fangs followed by from two to four teeth; complement of head shields complete except for loreal; scales smooth; in 13-19 rows; eyes rather small, pupil round; vertebral scales enlarged; usually dorsal vertebrae with lateral expansions connected with prezygapophyses and postzygapophyses. Nostril between two nasals; one preocular, two postoculars; subcaudals usually single.

Some thirteen species are known occupying territory in southern and southeastern Asia. Three species have been reported for Thailand. They may be distinguished by the following key:

KEY TO THAI SPECIES OF *Bungarus*

1. Scalerows, 13 about body; terminal subcaudals paired, other single. Black with an orange-yellow or red median dorsal stripe, and a red orange or yellow head..... *flaviceps*
   Scalerows, 15 (rarely 17); subcaudal scales, single throughout; vertebral scales strongly enlarged..... 2
2. Tail ending in a point; dorsal vertebrae do not form a ridge down back. Dorsum, black with 20-25 broad white cross-bars, the median part of each bar spotted with black; 7 to 10 bars on tail; head black above.... *candidus*

Tail ending bluntly, often with a swollen tip; spinous processes of vertebrae form a mid-dorsal ridge on body and tail; body alternately banded in black and yellow; a large black mark on nape reaches to between eyes, *fasciatus*

Members of the genus *Bungarus* have come to be known as Kraits. It is the English name generally applied to them in much of the literature. Most members of the genus seem to be very reluctant to bite and when teased do not become angry but continually try to hide their head under their coils or place the snout straight down against the earth. This habit is not confined to species occurring in Thailand. I once asked a Ghurka what the Krait was called in his country (Nepal). He replied, "'good snake' because it never bites.—But if it does it kills you."

Wall (1911) reports that the venom of the banded Krait, is less toxic, than cobra venom, and that there is no recorded case of human beings having been bitten! However he records that a bullock, bitten by a banded Krait, died "about 20 minutes or so later."

However, the bite does kill if sufficient venom is injected despite the fact that fatalities from them are relatively rare.

Bungarus flaviceps Reinhardt

Bungarus flaviceps Reinhardt, Vidensk. Selsk. Skrift., vol. 10, 1843, p. 267, pl. 3. fig. 4 (type-locality, Java).

Bungarus flaviceps flaviceps Reinhardt

(Fig. 85)

Bungarus flaviceps Reinhardt, Vidensk. Selsk. Skrift., vol. 10, 1843, p. 267, pl. 3, fig. 4 (type-locality, Java); Cantor, Journ. Asiat. Soc. Bengal, vol. 15, 1847, p. 1033, or Catalogue of the reptiles inhabiting the Malayan Peninsula (reprint of above 1847) p. 112; Theobald, Journ. Linn. Soc., vol. 10, Zoology, no. 41, May 30, 1868, pp. 63, 67 (Tenasserim); Flower, Proc. Zool. Soc. London, 1896, p. 894; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 371-372; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 200; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 245; Wall, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 21; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, no. 1, 1923, p. 61 (Nakhon Si Thammarat Mts.); M. Smith, Bull. Raffles Mus., no. 3, Apr., 1930, p. 67 (Nakhon Si Thammarat Mountains, 2000 ft.); Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 36 ("Bang Yai Jang, southwest of Rajaburi"); M. Smith, The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 410-411 ("Siam," Rat Buri); Tweedie, The snakes of Malaya, 1954, pp. 92-93.

Megaerophis flaviceps: Günther, The reptiles of British India, 1864, p. 346; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 33, 63 (separate); Sclater, Journ. Asiat. Soc. Bengal, vol. 60, 1891, p. 57; Bourret, Les serpents de l'Indochine, 1936, pp. 392-393.

Bungarus flaviceps flaviceps: Brongersma, Zool. Meded., vol. 30, no. 1, 1948, pp. 24-27 (excellent literature list and synonymy).

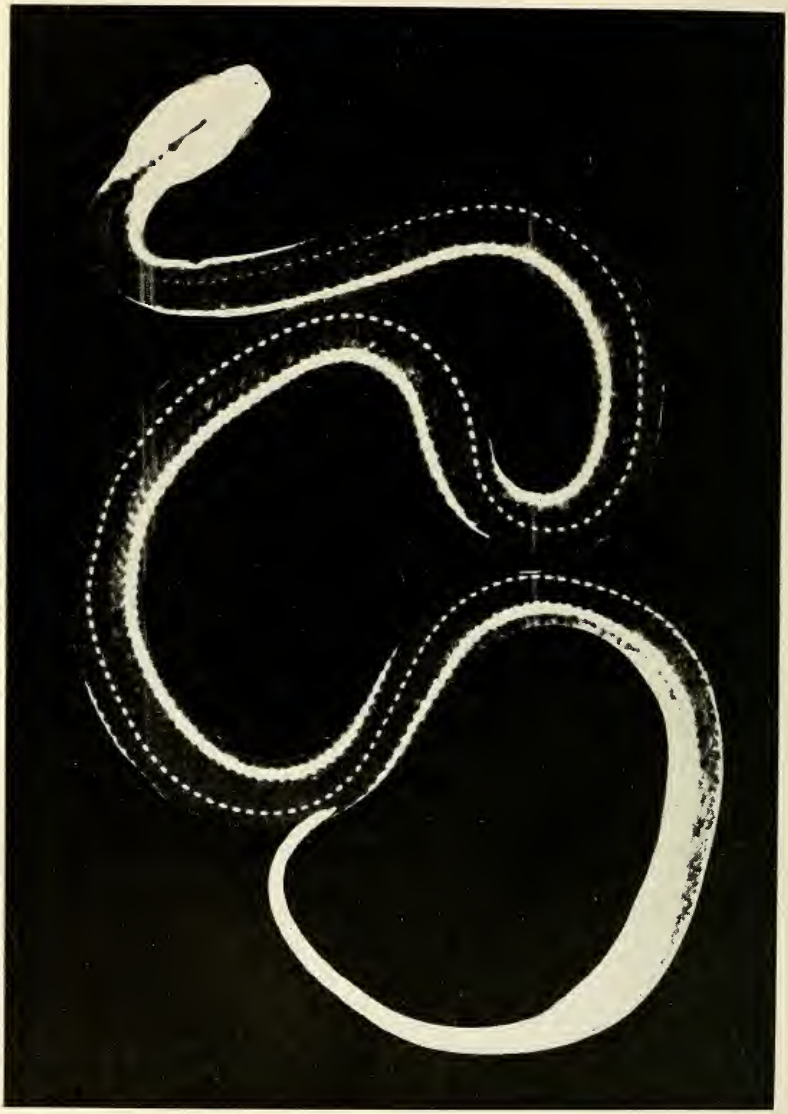

FIG. 85. *Bungarus flaviceps flaviceps* Reinhardt. (Young.) EHT-HMS No. m12, Fraser's Hill, Malaya. Actual total length, 398 mm.; tail, 52 mm.

Diagnosis: Large serpent (to 1850 mm.) with 13 scalerows throughout body; a distinct ridge on middle of back and tail; subcaudals paired. Black above with a red, orange, or yellowish head and tail and with a median dotted line and a lateral stripe of reddish orange or yellow; venter usually brown.

Description of species (from EHT-HMS No. M12, Fraser's Hill, Malaya): Rostral about one and a half times as wide as high, well visible above, its posterior border convex; internasals smaller than prefrontals; frontal hexagonal, sides practically parallel, longer than its distance to tip of snout, equal to length of parietal suture but shorter than parietals; frontal about twice as wide as supraoculars; nostril between two nasals, posterior one a little the larger; one preocular, not reaching top of head; two postoculars; temporals, 1 + 2 + 3; 2 + 2 + 3; seven supralabials, third and fourth border orbit; first infralabials in contact behind triangular mental; six infralabials, four touching anterior chinshields and first ventral.

Nineteen scales across occiput at fifth ventral; 13 scalerows on body as far as vent; scales smooth, the apical pits lacking; ventrals, 224; subcaudals, 54, the first 13 single, the next 40 divided, the terminal one single; anal, single.

Color: Above iridescent black with a series of red or orange spots one on each vertebral scale, but posteriorly fusing and forming a gradually widening stripe that is lost on the red or orange of the tail; a pair of lateral lines passing on outer scalerow and outer half of adjoining row; lower edge of outer row black. Head and neck red or orange as far as eighth ventral; a narrow black line begins on posterior tip of frontal, continues back and joins black dorsal coloration; venter blackish, the posterior edge of each scale somewhat lighter than remainder. The ventrals become lighter 50 scales before vent and farther back gradually become pure red or orange. This continues to end of tail except for a small black spot at tip.

Measurements in mm.: Young; snout to vent, 346; tail, 52; total length, 398; width of head, 9.4; length of head, 10.5.

Variation: Lower parts of the body may be orange or yellow, uniform or the ventrals maybe edged with brown. The lateral stripes are more distinct in the young.

The species is known to reach a total length of 1850 mm., the tail 220 mm. Rarely three postoculars are present. The ventrals of the female vary between 193 and 217; in males, 220-236; subcaudals 42-54; 47-53.

Remarks: The specimen described is a very young specimen, taken on Fraser's Hill, Malaya.

Bungarus candidus (Linnaeus)

(Fig. 86)

Coluber candidus Linnaeus, Museum S. R. M. Adolphi Friderici Regis Svecorum . . . 1754, pp. 32-33, pl. 7, fig. 1; Systema naturae, 10th Ed., 1758, p. 223, (type-locality, India).

Bungarus candidus: Boulenger, Catalogue of the Snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 368-369, (*part.*); Flower, Proc. Zool. Soc. London, 1899, pp. 689-690; Wall, Journ. Bombay Nat. Hist. Soc., vol. 18, 1908, p. 715, pl. 8, fig. 7; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 199-200; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 244-245, fig. 91; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 61; Bull. Raffles Mus., no. 3, 1930, p. 67; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 416-417; Tweedie, The snakes of Malaya, 1954, pp. 91-92; Taylor and Elbel, Univ. of Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1162 (Khorat).

Bungarus semifasciatus Boie, Isis, 1927, p. 552, (type-locality, Java); Günther, The reptiles of British India, 1864, p. 344.

Bungarus caeruleus: Boulenger, The fauna of British India, Ceylon and Burma . . . Reptilia and Batrachia, 1890, p. 388 (not of Schneider).

Diagnosis: Large snake, reaching a length of 1300 mm.; subcaudals, single; tail ending in a point; no dorsal ridge; scales in 15, more rarely 17 rows; anterior temporal longer than high; body with saddlelike blotches on a white or gray-white ground color.

Description of species (from No. 2673 ♂ Khao Chong, Trang, Thailand): Rostral low, narrowly visible above, wider than high; internasals a little more than half area of prefrontals, their suture little more than half that of prefrontals; latter scales angular laterally, each distinctly larger than frontal; frontal small, contained in distance to tip of snout 1.8 times, only half the length of parietals; nostril between two nasals; a preocular; supraocular only a little smaller than frontal; two postoculars; parietals narrow, elongate, nearly twice as long as wide; temporals, 1 + 2 + 3; supralabials, 7-7, third and fourth border eye, fifth and sixth largest; infralabials, 7-7, last small, first three bordering first chinshields, which are longer and wider than second pair. Scale formula: 21 (occiput), 17, 15, 15. Middle scalerow much widened. The nine anterior saddlelike blotches, in order, cover the following number of scale-lengths mesially: first, 21, 16, 13½, 12, 9, 7, 5 +, 5, 5; total number of blotches 22 on body, nine on tail. Ventrals, 222; anal, single; subcaudals, 53, undivided.

Color in life: Body white to ivory; top of head grayish black, followed by a chevron-shaped lighter area (in younger specimens) with considerable gray-black on each scale; first blotch touches black of head mesially; a series of iridescent bluish-black saddle-

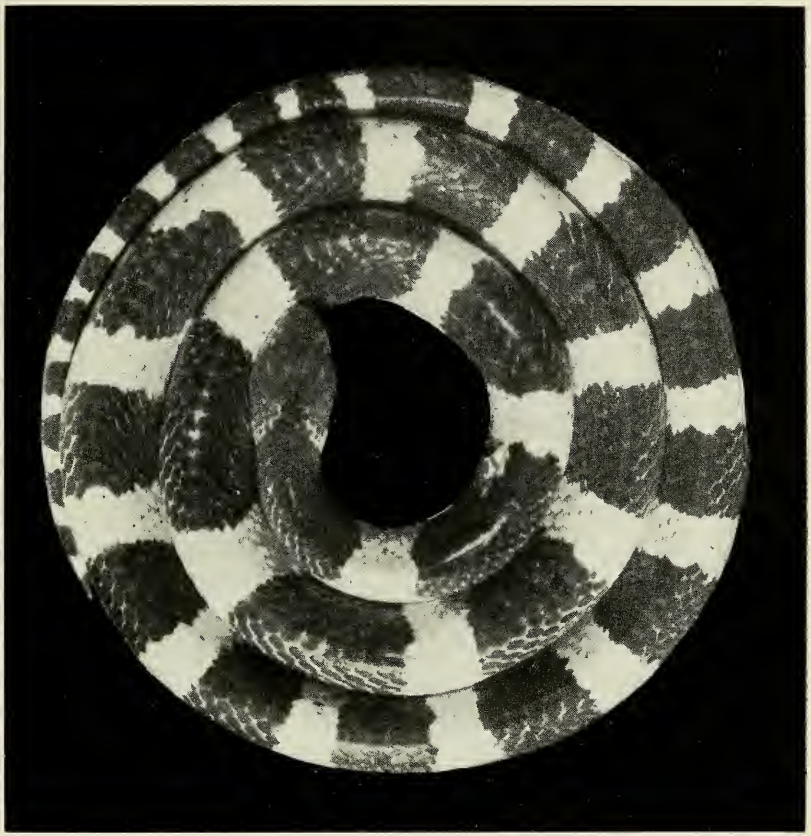

FIG. 86. *Bungarus candidus* (Linnaeus). EHT-HMS No. 2673 Forest Station, Khao Chong, Trang, southern Thailand. Actual total length, 1076.5 mm.; tail, 152.5 mm.

shaped blotches, widest on middle of dorsum, narrowing a little laterally, reaching onto edge of ventrals; intervening light bands narrower on mesial line, widening laterally, the light dorsal scales (except median and outer rows) each with a small black fleck. Venter ivory; toward posterior part of body posterior edges of ventrals with a faint amber shade; a few small subcaudal spots alternating with caudal spots.

Measuremnts in mm.: Snout to vent, 1076.5; tail, 152.5; width of head, 19; length of head, 31.

Variation: The ventrals range is from 194 to 237, the subcaudals from 37 to 56 (*fide* de Rooij). On the mainland specimens the scalerows are 15, while the ventrals range is from 209 to 219; subcaudals, 40 to 50 (*fide* M. Smith).

A specimen from Na Pradoo (P.K. No. 111), differs from the described specimen in certain points. There are 24 dorsal body spots and eight on the tail. The ventrals are 225 and there are 54 single subcaudals; temporals, 1 + 2 + 2. Supralabials white except on upper edges. It is difficult to discern a break in coloring between head and the first blotch, which has a length of 21 scales. Other following blotches have a length of respectively 10½, 9½, 7, 5½, 4½ scales. The total length is 878 mm.; the tail, 119 mm.; the width of head, 15; length of head, 21. The flecks on the dorsal scales are larger and more numerous, extending lower on the sides. There are no subcaudal spots, and the venter is whiter, lacking the faint amber tinge on the edges of the posterior ventrals.

Distribution: In Thailand the species has been found in the following provinces: Chon Buri (Siracha), Pattani, (Na Pradoo) and Trang (Khao Chong Forest Station). One has been reported from Nakon Ratchasima, and another from Koh Kut, an island in the Gulf of Siam. Elsewhere the species is known in Sumatra, Java, Borneo, Celebes, Malaya and Indo-China (Annam).

Remarks: The relatively small number of specimens, of this large and conspicuously marked snake in collections, suggests that it is wholly nocturnal in habit; otherwise it surely would be better known. The specimen described was one of two obtained at the same time at Khao Chong. They were performing what was presumed to be a typical combat "dance."

The place where they were discovered was at the edge of a small "waterfall" directly in front of a shelter house. Earlier in the day I had visited the spot hunting caecilians. It was an area where the solid rock floor was covered shallowly with a wet sod. This I removed from an area about 3 x 2 meters— an area which was promplty covered with water from four to twelve centimeters in depth. From the edge of this pool on one side was a rock retaining wall about two meters high, and fronting the wall a series of concrete steps. Under the wall was a hole going into the bank, a spot where I had captured certain frogs earlier in the day. At about 9:45 in the evening accompanied by Dr. Robert Elbel, and carrying a brilliantly lighted Coleman gasoline lantern, I left the shelter house, crossed the road and descended several steps down to the level of the stream, a distance of about 25 meters from the house. In the pool described above were two snakes, quickly recognized as *Bungarus candidus*. Their tails and perhaps half of their bodies were closely entwined, the anterior half to their bodies erect and

being thrust, rapidly, now on one side and now on the other side of their adversaries head. Each snake seemingly went through the same motions, all the while being propelled through the water by undulatory movement of the entwined portions of their bodies, back and forth, around and across the pool. They seemingly had no intention of leaving the pool and were wholly unaware of the light or of our presence. We watched this proceeding for perhaps two minutes when it appeared they might desist as they approached the hole under the wall where escape would have been easy. Rather than run a risk of their escape, I captured them, before they had lowered their bodies. It was only after capture that I discovered that both were males.

The caretaker at the forestry house who had collected snakes for a former forester, and who had been at the Station for some years declared that he had never seen this species of snake. This gives weight to the idea of their being largely or exclusively nocturnal in habit.

Bungarus fasciatus (Schneider)

(Fig. 87)

Pseudoboa fasciata Schneider, Historiae amphibiorum naturalis et literariae, fasc. 2, 1801, pp. 283-284 (based on Russell's Indian Serpents, vol. 1, 1796, p. 3, pl. 3 (type-locality, Bengal).

Bungarus annularis Daudin, Histoire naturelle des reptiles, vol. 5, 1803, pp. 265-269 (type-locality, Mansoor-Cottah, India).

Bungarus fasciatus: Fayrer, Thanatophidia of India, 1874, p. 10, pl. 9; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 32, 33, 63; Boulenger, The fauna of British India, Ceylon, and Burma . . . Reptilia and Batrachia, 1890, p. 388; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 366-367; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 198-199; Primrose, Journ. Bombay Nat. Hist. Soc., vol. 12, 1899, p. 589; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 344; *ibid.*, vol. 19, 1909, p. 835; *ibid.*, vol. 20, 1911, p. 933 (Col. pl.); *ibid.*, vol. 30, 1924, p. 22; Poisonous snakes of India, 1928, p. 14; Evans, Journ. Bombay Nat. Hist. Soc., vol. 16, 1905, p. 519; O. Smith, *ibid.*, vol. 21, 1911, p. 283; Kinear, *ibid.*, vol. 22, 1913, p. 635; Martin, *ibid.*, vol. 22, 1913, p. 635; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1915, p. 177 (photo). Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 163; de Rooij, Reptiles of the Indo-Australian Archipelago; Ophidia, 1917, p. 243; Sworder, Singapore naturalist, no. 3, 1924, pp. 19-22; M. Smith, Bull. Raffles Mus., No. 3, 1930, p. 67; Masson, Journ. Bombay N. Hist. Soc., vol. 34, 1930, p. 256; Pope, The reptiles of China, 1935, pp. 332-334, pl. 15; Bourret, Les serpents de l'Indochine, vol. 2, 1936, p. 385; Shaw, Shebbeare, and Barker, Journ. Bengal, Nat. Hist. Soc., vol. 16, 1942, p. 116; Smith, The fauna of British India, Ceylon, and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 411-412, fig. 133 B. Tweedie, The snakes of Malaya, 1954, pp. 90-91, pl. 8, fig. 22.

Bungarus fasciatus insularis Mell, Sitz. Ges. Nat. Fr. Berlin 1930, p. 325 (type-locality, Inselindien).

Bungarus fasciatus bifasciatus Mell, Sitz. Ges. Nat. Fr. Berlin, p. 325 (type-locality, Yao-Shan, Kwangsi Prov. China).

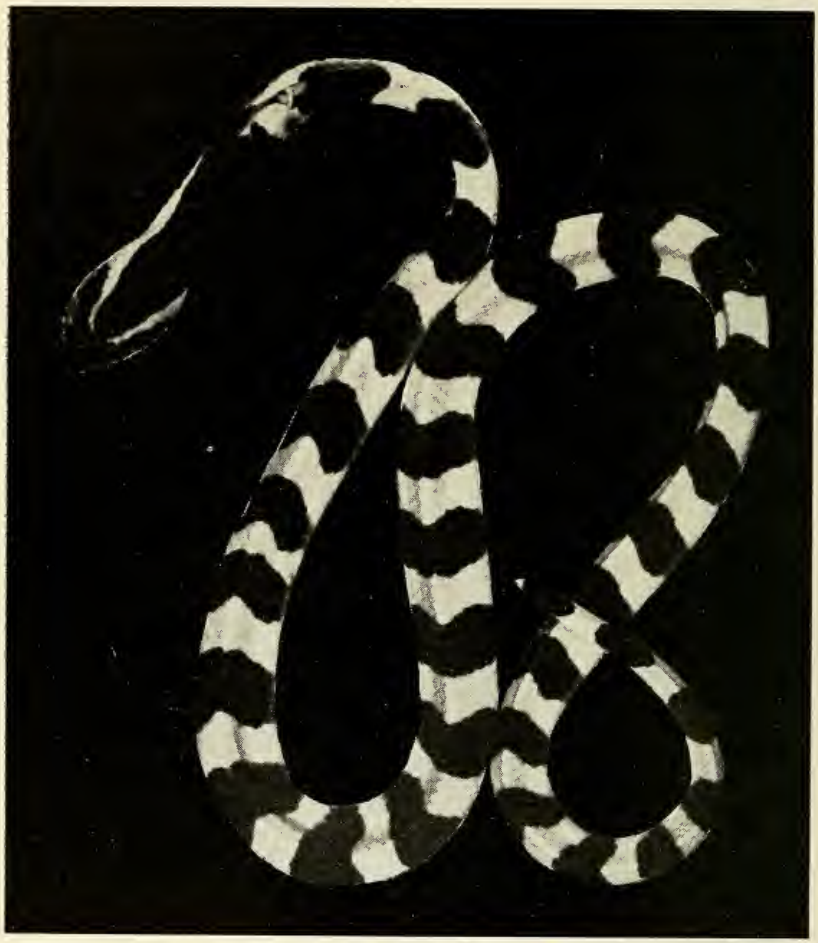

FIG. 87. *Bungarus fasciatus* (Schneider). EHT-HMS No. 22 yg. ♂, Chiang Mai, Thailand. Actual total length, 440 mm.; tail, 47 mm.

Diagnosis: A large serpent reaching a length of more than two meters. Scales in 15 rows throughout; tail blunt, more or less swollen at tip; a prominent ridge along middle of back and tail; one preocular, two postoculars. Alternately banded in black and yellow (or buff) the black bands being practically as broad as their interspaces; a large black symmetrical mark on nape extending forwards to level of eyes.

Description of species (from No. 22, Chiang Mai, Chiang Mai province, Thailand): Rostral broader than high, rather narrowly

visible above; internasals about two thirds as long as prefrontals; frontal longer than wide, longer than its distance from end of snout, shorter than parietals, its width slightly less than twice width of supraoculars; parietals truncate posteriorly, followed by a pair of scales lying between posterior temporals; nasal divided, anterior part largest and highest; posterior part depressed anteriorly; no loreal; a preocular, two postoculars, upper largest; temporals, 1 + 2 + 3; seven supralabials; third and fourth border eye, sixth the largest; infralabials seven, three bordering first chinshields which are distinctly larger than second pair, both pairs in contact with each other.

Scale-formula: 21 (about occiput), 17, 15, 15; all scales smooth, median dorsals widened, other scales forming somewhat diagonal transverse rows; ventrals, 226; subcaudals, 41 (single). A ridge along the back and tail; eye length equal to its distance from front of nostril. Tail blunt at tip.

Color: Generally yellowish or buff with a series of 28 black bands that surround the body and tail, usually a little narrower ventrally where they become rather dim and may be virtually interrupted on mid-ventral line; an elongate spot begins on neck, runs forward to head, where it narrows and terminates on frontal or merges with dark color of frontal region; small whitish marks on anterior head scales; supralabials largely white or yellow, often some black color along the upper borders and on sutures; underside of neck uniform cream; chin immaculate.

Measurements in mm.: Total length, 440; tail, 47; head-length, 18.5; head-width, 11.8.

Variation: This species exhibits a minimum of variation in most of its characters. The ventral range is from 200 to 234, the subcaudal range, 23 to 39.

Distribution: The species ranges from India throughout the Indo-Chinese subregion, the Malay peninsula and Archipelago. The snake is to be found throughout Thailand, more usually in the lowlands. In Burma it has been taken at an altitude of about 2300 m.

Remarks: The species may reach a size of 2125 mm., but few attain this length.

In Thailand it is called *Ngu sam lien* because of the sharp ridge on the back which give a triangular cross-section to the body.

Hatchlings measure 320-340 mm. in length. Dr. Malcolm Smith states that there is no authentic record of human beings having been bitten by this snake! He records a specimen from the city of Bangkok measuring 2020 m., the tail 150 mm. An Indian specimen has been reported with a length of 7 feet.

Genus *Naja* Laurenti

Naja Laurenti, Specimen medicum, exhibens synopsin reptilium emendatum, 1768, p. 90 (type of genus *Coluber naja* Linnaeus).

Diagnosis: Maxillary extending beyond palatine with large grooved poison-fangs; none or one small faintly grooved tooth following; anterior mandibular teeth longest; head not distinct from neck; no loreal scale; pupil round; nostril between two nasals with internasal and first labial touching or almost touching it. Body cylindrical; scales smooth, lacking apical pits, in diagonal transverse rows; subcaudals divided; no much-enlarged postparietal scales; elongate nuchal ribs capable of expanding the anterior part of the neck into a "hood."

The genus presents distinct taxonomic problems and there is considerable diversity of opinion as to the status of the various *kinds* of cobras in southeastern Asia. Are they species, subspecies, or "color varieties"? Boulenger (1896) lists some six "var." which may possibly be interpreted as subspecies of his *Naia tripudians.* Wall who studied Indian forms likewise recognized a number of forms in India and southeastern Asia. Pope (1935) recognized only a single subspecies in China; and Bourret (1936) recognized two in Indo-China. Recently (1960) Deraniyagala has presented a new repartition of the Asiatic species, a paper I have not seen.

Malcolm Smith (1943) recognized the presence of one subspecies occurring in Thailand, a form usually bearing a monocellate spot on the upper surface of the neck. This presumably represents the typical *N. naja kaouthia.* He describes the young as being olivaceus, brownish to black above, with or without a yellow or orange colored, O-shaped, or monocellate, mark upon the hood. He further mentions a report of bright green or blue cobras in Burma and at Nan, north Thailand; and mentions a green specimen from Den Chai, Lampang.

Since the variation from the typical coloration of *Naja naja kaouthia* is so great, the recognition of the variations as true cobras is very difficult for the layman. To facilitate such recognition I offer brief descriptions of the various kinds. I am not wholly

convinced that they should not be considered subspecies or perhaps in some cases even species. My personal experience with these "varieties" is such that I cannot decide, and I leave them without individual names.

Naja naja kaouthia Lesson *in* Férussac

(Fig. 88)

Naja kaouthia Lesson *in* Férussac, Bull. Sci. Nat. 1831, vol. 25, 1831, p. 122; and Belanger, Voy. Orient. Rept. Sept. 1832, p. 312, pl. 2 (type-locality, Bengal).

Naja naja kaouthia, M. Smith, Rec. Ind., vol. 42, 1940, p. 485; The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Dec. 1943, pp. 428, 531-535, fig. 138, i. j.

Naja fasciata Wall, Journ. Bombay Nat. Hist. Soc., vol. 22, p. 246 (var.) includes (*kaouthia* Lesson, *larvata* Cantor *scopinucha* Cope).

Diagnosis: Hood with a single "monocle" or O-shaped cream mark; 28 to 26 scalerows on neck, 21 on middle of body. Two small black spots on sides of throat with one to three dark bars on neck and anterior part of body; remainder of venter usually dark; subcaudal region light or cream; transverse scalerows chevron-shaped, made distinct by slightly darker edges on scales, and lighter color between scales.

Description of subspecies (from No. 2413, Kanchanaburi typical form): Rostral one and one third times as wide as high, narrowly visible above; internasals large, in contract laterally with nasals and preocular; prefrontals narrower but about as long as internasals; frontal small, much shorter than supraoculars, but of same width very much shorter than its distance from rostral, much shorter than parietals; a single small postoccipital scale between upper secondary temporals. Nasal divided, posterior part higher but shorter than anterior part; no loreal; a preocular (on right side a second small subocular below the normal preocular); three postoculars; two large anterior temporals followed by four irregular secondary temporals; seven supralabials, third and fourth bordering orbit, last labial elongate. Mental much smaller than rostral, its labial border little more than half as long as that of rostral; first chinshields slightly wider but scarcely as long as second pair; eight infralabials, four bordering first chinshields; a small cuneate scale on labial border between fourth and fifth infralabial; eye small, its diameter a little more than half its distance from oral border.

Scale-formula: 29, 21, 15(13); ventrals, ♂ 174; subcaudals, 57; anal, single.

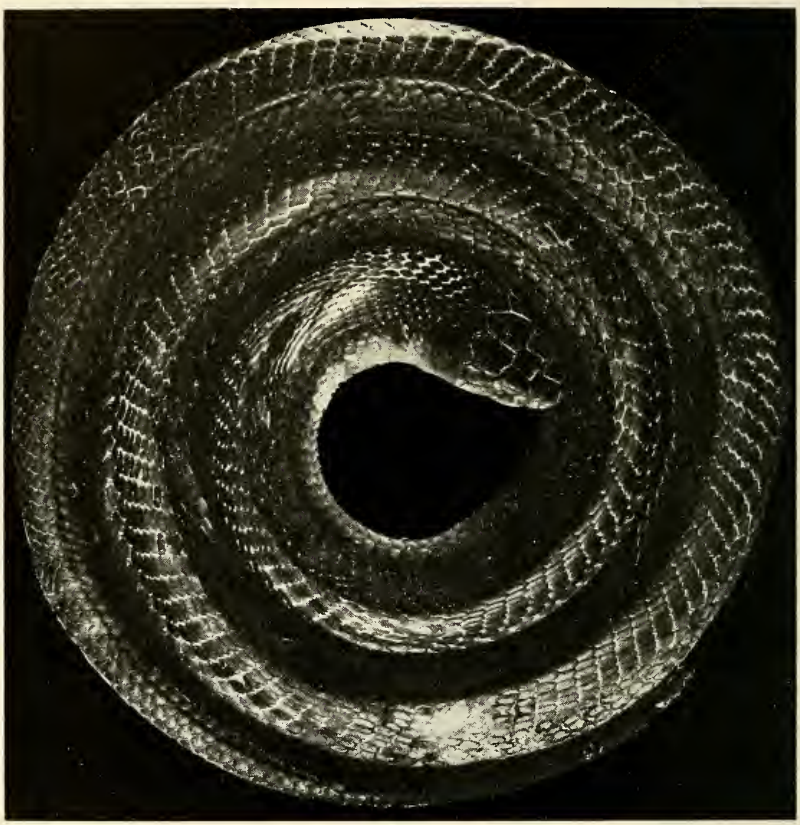

FIG. 88. *Naja naja kaouthia* Lesson *in* Férussac. No. 34822, Phatthalung, Phatthalung province. Actual total length, 1430 mm.; tail, 257 mm.

Color: Dark brown above, of a slightly lighter shade anteriorly; posterior edges of scales a trifle darker; top of head nearly uniformly dark growing lighter on side of head with whitish areas on last three supralabials; an O-shaped lighter spot with a dark center and a narrow black border on "hood"; skin between scales dark with numerous dashlike white marks concealed (unless scales are separated). Chin and throat ivory with a black spot on ends of the sixth to ninth ventrals; after an interval of three ivory-colored ventrals, a black bar covering seven ventrals; five ivory scales follow, then a cloudy area covering ten ventrals; after one or two ivory scales the remainder of the venter is dark gray-brown, at least anteriorly, the pigment appearing as discrete flecks; subcaudal area light ivory with brownish flecks on scale edges.

Variation: In Thailand specimens the range of variation in this form is not great. Some specimens tend to become a little lighter in old age and the monocular mark on the hood may be less distinct. There may be as many as four black bars on the venter separated by narrower lighter areas. Occasional specimens showing a little more light color between the scales, appear to be marked anteriorly with dim narrow light dorsal bands at intervals.

Distribution: This form is known from Bengal, Burma and Thailand, especially in the large rice-growing areas. Specimens are known from Narathiwat, Pattani, Nonthaburi, Ayutthaya, Kanchanaburi and Bangkok, and presumably occurs throughout the country.

Remarks: The cobra di capello (Portuguese name) is one of the most widely known serpents. In its abbreviated form 'cobra' the name is widely known as the name "*Boa constrictor,*" or "rattlesnake," although the name 'cobra' is applicable, in the Portuguese, to most kinds of snakes.

The snake is rather timid and stories of its aggressiveness are usually exaggerated. In the rice fields it has become semiaquatic. Here it finds frogs in abundance and certain rodents that burrow into the low walls of the rice paddies. These animals represent the major food of the cobra.

Almost all herpetologists who have had occasion to deal taxonomically with the cobras of India and southeastern Asia have found difficulty. As remarked, there are several 'forms' which may be species, subspecies or color varieties. If regarded as subspecies we may have the phenomenon of three subspecies occurring in a single locality.

It is known that the cobra is carried about by snake charmers, and one explanation might be that escaped specimens from distant localities might cross with a local population and produce individuals difficult to classify. However it is the fact that some of the kinds are separated by scale differences which tend to be fairly constant, as well as by specific pattern differences.

In Thailand there are several known forms that are easily recognized, and perhaps others that may or may not fit into this grouping. Malcolm Smith has reported a green or olive-green cobra from Den Chai, south of Lampang, Thailand, "The greenness was pronounced." Wall (1913) also reports the presence of green (or blue) cobras in the Khasi Hills in Burma and at Nan in north "Siam." Wall has proposed the name *viridis* for these.

SYNOPSIS OF THE THAI "VARIETIES" OF *Naja n. kaouthia*

1. Venter uniform yellowish white with small black spots on throat the light color tending to encroach on sides of neck; above, body fawn, scales edged with lavender-brown; four to ten light fawn bands edged with black-brown across body, no nuchal mark on hood. Ventrals, 180-182; subcaudals, 50-52; totals, 230-234; scalerows on neck, 25, mid-body, 19, preceding vent, 14 (15). One cuneate scale on lower lip; three postparietals; rostral barely visible above. (See Figure 89)..... *Variety A*

   Without marks on throat; no bands on posterior part of body; with or without a nuchal mark..... 2

2. Venter light yellow-ivory to gray-ivory; posterior ventral scales edged with light gray; above nearly uniform grayish fawn with two elongate gray-black nuchal marks separated by a fawn area extending back to level of 19th ventral; no bands of black or white on throat. Ventrals, 172; subcaudals, 57; total, 229; scalerows on neck, 31; mid-body, 21, preceding vent, 15; two small cuneate scales on lower lip excluding (or not) the fifth labial from mouth border; (See fig. 90)..... *Variety B*

   Venter not light; usually two black and two white bands following cream-white area on chin and throat. A nuchal mark present or absent, if present, variable..... 3

3. Almost uniform brownish black on head, body, and tail. No nuchal mark; two black and two white transverse bands on throat (trace of a third light band), venter otherwise black; some cream flecks on subcaudal area; ventrals, 164; subcaudals, 50; total, 214. Scalerows: 29, 19, 13; one cuneate on lower lip between fourth and fifth infralabials; one median postparietal scale; second chinshields in contact. (Detailed description given), *Variety C*

   A nuchal, "monocellate type" mark present; venter variable..... 4

4. A quadrangular or diamond-shaped cream nuchal spot, bordered by black, surrounding a large deep-black oval spot; a small oval black spot on each side of the large mark. Body above brownish, black on head; anterior half of body dove-gray; latter half of body darkening first to brownish, then to purplish brown, and to black; small black spots on throat; two dark blackish gray bands separated by cream bands on throat; remainder of venter blackish; subcaudal scales cream, edged with black. Ventrals, 170; subcaudals, 57. Scalerows: 32, 21, 15; one cuneate scale present; rostral scarcely visible above. (Detailed description)..... *Variety D*

   Nuchal mark not quadrangular..... 5

5. Above dark blackish brown; an elongate oval light brown area outlined in black and enclosing a black oval mark on nuchal region (hood); on underside of neck two black and two cream bands, the second of these continuous with the cream of the venter. This cream color becomes yellowish gray posteriorly and the venter has two lateral bands of gray-olive on sides of ventral scales, throughout rest of body. Ventrals, 177; subcaudals, 58; scalerows: 31, 23, 15; three cuneate scales excluding fifth supralabial from labial border; 3 postparietals. Frontal nearly quadrangular, short; rostral strongly visible above; lower primary and lower secondary temporals very large..... Typical *kaouthia*

   (This is the typical form with a distinct monocellate hood mark, see description and figure 88.)

   Venter not so marked..... 6

6. Not green; generally blackish above with head olive brown; light on sides; a narrow ring of yellow-cream surrounding a black oval spot in nuchal region. When epidermis is removed scales show somewhat lighter centers. Chin and throat pure cream, color encroaching on first scalerow and with small black spots on each side; sides of nuchal region (hood) blacker than remainder of dorsum. Ventrals, 174; subcaudals, 57; total, 231 (Na Pradoo, Pattani). Ventrals, 161; subcaudals, 49; total, 210 (Bang Saen, Chon Buri); three postparietals; two lower temporals largest. (This is possibly a juvenile of the typical form)..... *Variety E*

Dorsal color green. Another variety mentioned by Wall (1913) and Malcolm Smith (1943) is a green cobra occurring in northern Thailand. Smith has seen one from Den Chai, south of Lampang; Wall has reported the species as occurring at Nan, northern Thailand. The color described as "bright green or blue"..... *Variety F*

Naja naja kaouthia (Variety A)

(Fig. 89)

Description (from C.U. No. 2619, Na Pradoo, Pattani, southern Thailand): Rostral about one-and-one-fourth times wider than high, narrowly but plainly visible above; internasals a little smaller then prefrontals, touching preocular; prefrontals wider anteriorly than posteriorly, their common suture double that between internasals; frontal moderate, its length equal to its distance from tip to snout, about as long as parietal suture, but shorter than parietal; three postparietals between posterior upper temporals; nostril between two nasals, bordered above by an internasal and below by first supralabial; preocular not reaching upper surface of head; three postoculars; two large anterior temporals, followed by an irregular group of small temporal scales; supraoculars in the following ascending order of size: 2, 1, 3, 6, 5, 2, 7 but the last five not very different in size. Infralabials eight, four bordering anterior chinshields; a small cuneate scale on lower labial border between fourth and fifth infralabials (on one side excluding the fifth infralabial from labial border); second chinshields smaller than first, and separated by one or two scales.

Scalerow-formula: 22 occiput, 25 about neck, 19 at middle of body; 15 (14) before vent. Ventrals, 182; subcaudals, 52; nine bands on body, three on tail.

Color: Top of head brownish (grayish when epidermis is shed); sides of head brownish ivory. Above generally light brown, scales partly edged with fawn; a series of nine light bands crossing body their edges darker brown, anteriorly less than width of one transverse scalerow, posteriorly the width of two scalerows. The bands are rather equally spaced except that none are present on anterior fifth of body; entire chin and venter white, except that outer edges of ventrals have a narrow edging of pigment; a median black spot on fifth to eighth ventral with two lateral spots on the tenth and eleventh.

Measurements in mm. (Nos. 2619 and 2618 respectively): Total length, 568, 477; tail, 85, 68; width of head, 15.2, 15; length of head, 23, 19.

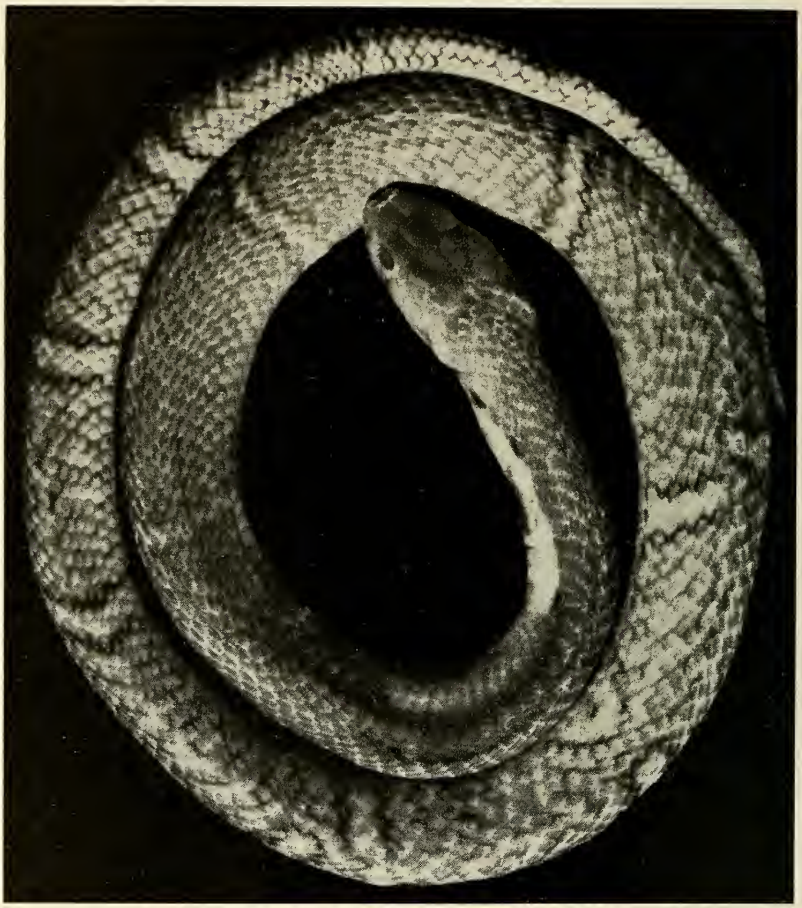

FIG. 89. *Naja naja kaouthia* Lesson *in* Férussac. Variety. C.U. No. 2619, Na Pradoo, Pattani, province southern Thailand. Actual total length, 568 mm.; tail, 85 mm. (Variety A.)

Remarks: The second specimen shows only five lighter bands on the latter half of the body and the median black spot on the throat is absent. The squamation on the heads is identical. The scale-formula is the same. Ventrals, 180; subcaudals, 50; anal single.

The monocellate form occurs in the same area.

Naja naja kaouthia (Variety B)

(Fig. 90)

Descripion of Variety B (from No. 33545, ♂ locality uncertain): Rostral nearly twice as wide as high, barely visible above; internasals as large in area as prefrontals, touching preocular; frontal

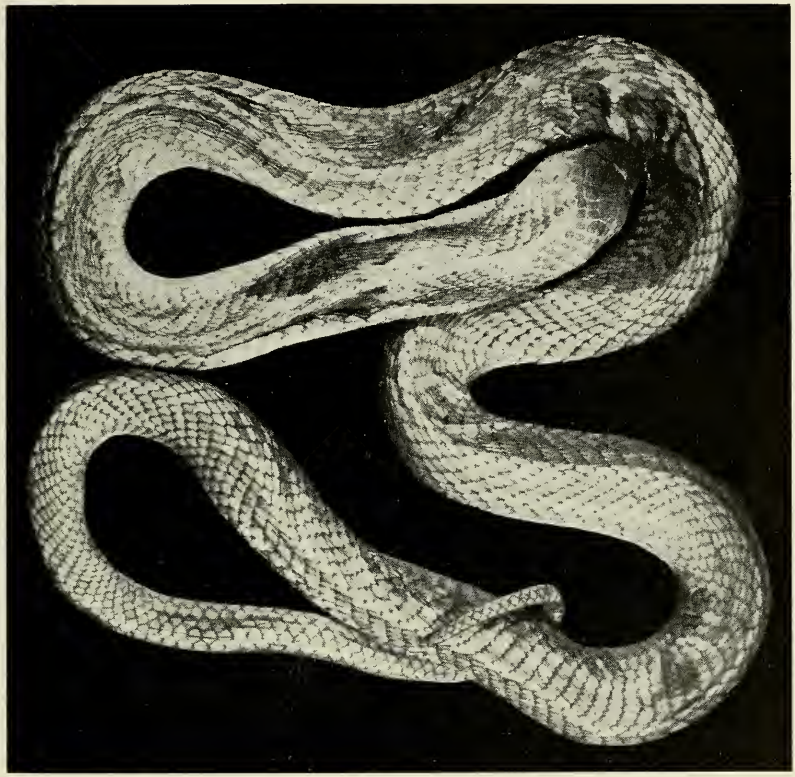

FIG. 90. *Naja naja kaouthia* Lesson *in* Férussac. No. 33545, Thailand. Actual total length, 1215 mm.; tail, 210 mm. (Variety B.)

almost quadrangular, wider and shorter than supraoculars, equal to its distance from internasals, about half as long as parietals; nostril between two nasals, anterior the larger; nostril bordered above by internasal, below by first supralabial; seven supralabials in following ascending order of size: 2, 1, 4, 6, 3, 5, 7, third and fourth enter eye. Two large anterior temporals followed by three, the lower one of which is about as large as the two anterior; eight infralabials, four bordering first chinshields; mental about one half width of rostral; between fourth and fifth, and fifth and sixth are two tiny cuneate scales bordering lip, excluding or almost excluding fifth supralabial from oral border.

Scalerow-formula: 24 occiput, 31 neck, 21 mid-body, 15 before vent. Ventrals, 172; subcaudals, 57; anal, single.

Color in life: Body a nearly uniform yellowish olive, the edges of most of the scales grayish with the skin dark between scales.

Beginning behind occiput on each side, a dark gray area covering nine scalerows, but narrowing to three rows at level of eleventh ventral, then again widening to cover ten rows, then narrowing to one row and terminating at level of the 19th ventral. Middorsally the light-brown color is narrowed to three scalerows then widens to eleven scalerows and again narrows to four rows, again widening and merging into dorsal coloration of remainder or dorsum. Chin, neck, and venter anteriorly yellowish ivory, later developing to a dirty brownish white. Latter half of body has ventrals dimly edged with gray. Subcaudal area ivory-white. Top of head nearly uniform olive-brown.

Measurements in mm.: Total length, 1215; tail, 210; width of head, 30; length of head, 42.

Naja naja kaouthia (Variety C)

Description of Variety C (from No. 34246, Bang Saen, Chon Buri, southeastern Thailand): Rostral at least one-third wider than high, well visible above; internasals large, wide laterally, touching the preocular; prefrontals of about same area as internasals, in contact laterally with preocular; frontal moderately small, equal to its distance from rostral, only a little larger than prefrontals, shorter but slightly wider than supraoculars, much shorter than the parietals. Latter scales longer than wide; one somewhat enlarged median postparietal scale; nasal completely divided, anterior part largest; nostril practically as large as anterior portion of nasal, bordered below by first supralabial; a single preocular widely separated from frontal; three postoculars; two anterior temporals; seven supralabials in following ascending order of size: 2, 1, 3, 4, 5, 6, 7; mental small; eight infralabials, first four bordering first chinshields which are a little wider than second pair. A small intercalated cuneate scale on labial border between the fourth and fifth infralabials.

Scale-formula: 25 (occiput), 27, 19, 13, scales without pits, but arranged in oblique transverse rows, the median longitudinal rows smallest; scales on posterior part of body larger, the three outer rows larger than others. Ventrals, 164; subcaudals, 50, paired; anal, single.

Color in life: Brownish black to black on head, body, and tail; chin brownish white with a pair of yellow spots; first 14 ventrals gray-olive; next eight ventrals blackish followed by three olive ventrals with two small yellow spots. At intervals occasional small

yellow spots on brownish-mottled, dark-olive venter. Sides of head brownish olive; subcaudal area somewhat brownish gray with some yellowish color between paired subcaudals.

Measurements in mm.: Total length, 1214; tail, 175; length of head, 56; width of head, 34.

Remarks: The specimen was captured alive on the campus of the Teachers College at Bang Saen, Chon Buri province.

At Bangkok while making moving pictures of the animal crawling on the ground, it discharged its venom towards me as evidenced by a spray of amber droplets of the venom on my eye-glasses.

Naja naja kaouthia (Variety D)

Description of Variety D (from C.U. 2686): Rostral ½ wider than high, scarcely visible above; internasals large, about equal in size to prefrontals, but prefrontal suture longer than internasal suture; frontal small, its length much less than its distance from tip of snout (8 mm. x 12.5 mm.), a little wider but shorter than supraoculars; parietals rather narrow, elongate (15 mm.); nasal divided; no loreal; a preocular and three postoculars; temporal 2 + 3, first temporals large; supralabials in following ascending order of size: 2, 1, 4, 5, 6, 3, 7; eye diameter slightly less than distance of eye from lip; infralabials seven, four touching first pair of chinshields.

Scalerow-formula: 32, 21, 15; scales longer than wide, arranged in diagonal transverse rows. Ventrals, 170; anal, single; subcaudals, 57, paired.

Color: Head above brownish or grayish olive-brown; sides of head, light horn color; a white quadrangular or diamond-shaped dark-edged spot surrounding a large oval black spot, with a small oval black spot on each side, the surrounding skin blackish, the scales grayish. Dorsally anterior half of body dove-gray, skin between scales blackish; in latter half of body scales darkening; brownish or purplish brown to blackish laterally.

Chin and throat pure white with a black spot on each end of seventh and eighth ventral scales; 12th to 18th ventrals lightly clouded gray-brown, followed by four white ventrals; next eleven ventrals grayish with the following three ventrals light. Beyond these venter gradually growing darker, becoming black then gradually attaining a transverse grayish streak. Anal region light; subcaudals light cream, strongly edged with black or brownish black.

Measurements in mm.: Total length, 1305; tail, 222; width of head, 28; length of head, 41.

Remarks: This specimen is in the collection at Chulalongkorn University. It is a Thai specimen from a locality unknown to me. The sharply angulate nuchal mark has not been recorded for Thailand specimens.

Genus *Dendraspis* Fitzinger

Dendraspis Fitzinger, Systema reptilium, 1843, p. 28 (type of genus, *bungarus* = *hannah*).

Since the name *Hamadryas* of Cantor, 1836, is preoccupied by *Hamadryas* Hubner, 1806, it would appear that Fitzinger's name *Dendraspis,* 1843, is the next name available. The genus is presumably monotypic.

Diagnosis: Large poisonous snakes reaching a length of five, to five and one-half meters. Scales in 15 rows at mid-body; anterior subcaudals single; poison-fangs followed by three teeth; a pair of large occipital scales with occasionally an interoccipital. No small (cuneate) scale on lower jaw between labials; neck slightly dilatable; young with deep black and yellow bands.

By the characters listed this snake is amply differentiated generically from the genus *Naja.* It is a wide-spread species that shows a minimum of variation save that pertaining to age. Because of its great size (the largest poisonous snake), and its name (King Cobra), it has been the subject of much popular literature. Much that has been written while largely true, tends to exaggerate its dangerous qualities. There is at least one account in scientific literature, where the snake is presumed to have made an attack without provocation. But at the same time there is given evidence that the snake does not attack unprovoked. More frequently it attempts to escape from the presence of man under ordinary circumstances.

The species has a well-known habit of nest building. A pile of leaves and twigs serve for the nest, the material often being accumulated by the technique of shoving the materials together with the body. The eggs are deposited on the lower layers of this material, and covered. One of the pair usually occupies the upper part of the piled material, guarding the eggs. A favorite place for this nest building is in clumps of bamboo that normally accumulate leaves between the stems.

The King Cobra is ophiophagus and thus requires a considerable territory for food finding. In consequence the snake is rarely regarded as common in any locality. In places where reports claim the snake is common, one usually finds that the common rat snakes of the genus *Ptyas* are mistaken for the King Cobra.

While collecting under police escort near Bhetong, Yala, the captain of police who also had accompanied me repeatedly warned me of the King Cobra. I suggested that rat snakes were often mistaken for the cobra, but he assured me that he could distinguish the cobra. Later in the day he spotted a large snake, with a length of approximately eight feet, its head reared, at the edge of thick jungle. "Cobra," he said, "Now let me see you capture it."

The chance of getting the snake was small. I crossed a tiny rivulet and approached the snake with extreme slowness until I stood within reach of it and with a sudden thrust grabbed it by the head and neck. Despite all my protestations that the snake was a rat snake it remained a King Cobra as far as he was concerned. The story was still extant two years later, of my capture by this method of a King Cobra. It makes a better story so.

Dendraspis hannah (Cantor)

Hamadryas hannah Cantor, Asiatic research, vol. 19, 1836, p. 187, pls. 10-12 (type-locality, Sandarbans, near Calcutta, India).

Naja hannah: Wall, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 189, pl. (monographic treatment); *ibid.*, vol. 30, 1925, pp. 242, 820; *ibid.*, vol. 21, 1926, p. 564, fig.; The poisonous snakes of India, 1928, p. 27; Aagaard, Journ. Nat. Hist. Soc. Siam, vol. 6, 1924, p. 315; Pope, The reptiles of China, 1935, pp. 346-348, pl. 16, A, B; Bourret, Les serpents de l'Indochine, 1936, p. 299; M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 485; The fauna of British India, including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 436-439; Tweedie, The snakes of Malaya, 1954, pp. 98-100, fig. 23, b, c.

Naja bungarus Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 476, pl. 17, figs. 8, 9 (type-locality, Sumatra); Schlegel, and Müller, Verh. Overz. Bes Nederland Indië, Rept., 1844, p. 71, pl. 10; Peters, Mon. Berl. Acad., 1861, p. 690; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 392-393; Sclater, List of the snakes in the India Museum, 1891, p. 59; Wasey, Journ. Bombay Nat. Hist. Soc., vol. 7, 1892; p. 257; Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 386; Flower, Proc. Zool. Soc. London, 1899, p. 691; Bannerman, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, p. 407; Annandale, Journ. Asiat. Soc. Bengal, 1905, p. 176; Wall, Journ. Bombay Nat. Hist. Soc., vol. 17, 1906, p. 303; *ibid.*, vol. 18, 1908, p. 331; The poisonous terrestrial snakes of our British Indian Dominions . . . 1907, p. 26; 1908, p. 33; Mocquard, Les reptiles l'Indo-chine, 1907, p. 53; Sarasin, Zool. Jahr. Jena, 1910, p. 144; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 202-203, fig. 60, (*Naia*); Acton and Knowles, Journ. Ind. Med. Res., 1914, p. 52; Prashad, Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, p. 585; Fenton, *ibid.*, vol. 25, 1917, p. 151; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 249, figs. 93, 94.

Hamadryas ophiophagus Cantor, Proc. Zool. Soc. London, 1839, p. 32 (type-locality, Bengal); Journ. Asiat. Soc., Bengal, vol. 16, pt. 2, 1847, p. 116.

Trimeresurus ophiophagus: Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, pp. 1245-1247.

Hamadryas elaps: Günther, Catalogue of the Colubrine snakes in the British Museum, 1859, p. 219; Theobald, Journ. Linn. Soc. Zool., vol. 10, no. 41, May 30, 1868, pp. 60-61.

Ophiophagus elaps: Günther, Reptiles of British India, 1864, p. 341; Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 210; Anderson, Proc. Zool. Soc. London, 1871, p. 188; Fayrer, Thanatophidia of India, 1874, pls. 7, 8; Phipson, Journ. Bombay Nat. Hist. Soc., vol. 2, 1887, p. 245; Boettger, Ber. Offenb. Ver. Nat., 1888, p. 86.

Naja fasciata Peters, Monats. Akad. Wiss. Berlin, 1861, p. 689.

Naja vittata Elliot, Madras Journ. Litt. and Sci., vol. 11, 1840, p. 39, pl. 1 (type-locality, at sea, near Madras).

Trimeresurus bungarus: Jan, Rev. Mag. Zool., 1859, p. 129; Jan and Sordelli, Iconographie générale, livr. 44, 1873, pl. 4 (Singapore, Siam).

Hamadryas elaps: Theobald, Descriptive Catalogue of the reptiles of British India, 1876, p. 209.

Naja ingens Van Hasselt, Versl. A.K. Amsterdam, vol. 17, 1882, p. 140 (not seen).

Naja tripudians sumatrana Müller, Verh. Nat. Ges. Basel, vol. 8, 1887, p. 277 (Sumatra).

Diagnosis: See generic diagnosis.

Description of species (from No. 1653 ♀, Khao Kampan): Rostral one and one-half times as wide as high, part visible above triangular; internasals wider than long, touching nasals laterally; prefrontals wider than long, wedged between preocular and second nasal; frontal short, nearly truncate anteriorly, shorter than its distance from rostral, much shorter than parietals, scarcely as wide as supraoculars; parietals longer than wide, a pair of large occipitals, forming a median suture; nasal divided; preocular moderate, separated from internasals, not reaching upper surface of head; three postoculars, two touching upper anterior temporal, two touching lower anterior; temporals, 2 + 2; seven supralabials, first in contact with both nasals; third and fourth bordering orbit. Mental small, convex behind; eight infralabials, four touching first chinshields which are wider but shorter than second pair.

Scale-formula: 19 on occiput; 21 on neck, 15 at mid-body; 15 before vent; three median scalerows somewhat enlarged on much of the body. Ventrals, 266; anal, single; subcaudals, 106, five single and 101 divided except terminal.

Color in life: Above generally olive; black-edged scales on back of head. Towards posterior part of body and on tail, lighter scales gradually becoming darker on the edges. On tail, scales yellowish ivory with well-defined black edges. Chin and throat yellowish and ivory with some grayish-olive areas; remainder of ventrals gray with some ivory flecks growing lighter toward vent; subcaudals dull ivory each scale black-edged.

Measurements in mm.: Total length, 2690; snout to vent, 2123; tail, 567; width of head, 44; length of head, 54.

Variation: The number of ventrals and subcaudals vary between 240 and 266; 84 and 106. The usual number of scalerows on the neck is 17 or 19. A small interoccipital scale may be present. The coloration of young specimens is deep black with transverse narrow yellow bands. Four of the bands cross the head.

Distribution: In Thailand the snake has been taken in Chiang Mai, Yala and Narathiwat provinces but is known to occur widely in the country.

Outside of Thailand the species ranges from Peninsular India to the Himalayas (not in Ceylon), Burma, Indo-China, Southern China, Malaya, and the Indo-Australian Archipelago as far east as Luzon in the Philippines. It appears to reach its maximum size in the Malay peninsula.

Remarks: The transverse marks of the very young are often retained in the adult as visible lighter marks, the lighter color being largely on the skin between the scales.

The species is oviparous, the number of eggs reported vary between 21 and 40. The young, just hatched, measure from 500 to 530 millimeters in length.

The described specimen was captured in a cave in Khao Kampan, Pattani.

Genus *Maticora* Gray

Maticora Gray, Illustrations of Indian Zoology, 1834, pl. 86, fig. 2 (type, *lineata*).

Doliophis Girard, Proc. Acad. Nat. Sci. Philadelphia, 1852, p. 182; U. S. Exploring Expedition., Herpetology, 1858, p. 175 (type of genus *flaviceps*).

Diagnosis: Very small to large snakes. No loreal; scales smooth without pits in 13 rows; head sometimes red, relatively small, not separated from neck; eye small with round pupil; tail short, often red, the subcaudals paired; anal divided; maxillary extending beyond palatine, bearing a pair of large grooved fangs; prefrontal bones in contact; poison-glands extending into body cavity, increasing in diameter posteriorly.

This genus is represented in Thailand by two species, *Maticora bivirgata,* and *M. intestinalis.* Dr. L. D. Brongersma has revised the forms under *bivirgata,* recognizing three forms identified as subspecies. The typical form *b. bivirgata* occurs in Java; *b. tetrataenia* in Borneo and very doubtfully also in Java and Sumatra; *b. flaviceps* is a subspecies occurring in Sumatra and nearby islands, and in the Malay Peninsula.

Loveridge in (1944) lists in his key eight subspecies of *intestinalis* and one full species, but is not certain but that some listed as subspecies may actually be species.

A paper published by A. M. R. Wegner in 1954 discusses the geographic ranges of the so-called subspecies of *intestinalis*. I have not seen this.

KEY TO THAI SPECIES OF MATICORA

1. Venter red, immaculate; head and tail red; no dorsal spots (normally); ventral range, males, 260 to 277; females, 230 to 246... *bivirgata flaviceps*
2. Venter barred with black and red (or ivory-cream, or pink). A median yellow or yellow-brown dorsal line flanked by two black lines; venter with about 40 black bars; no dorsal spotting; ventrals, 213 to 266; in Thai specimens, 237 to 240..... *intestinalis intestinalis*

Maticora bivirgata (H. Boie *in* F. Boie)

Maticora bivirgata flaviceps (Cantor)

Elaps bivirgatus H. Boie (*in* F. Boie), Isis, 1827, p. 556, (type-locality, by inference, Java); Brongersma, Zool. Meded. Uitg. Rijksm. Nat. Hist. Leiden, vol. 30, no. 1, Oct. 28, 1948, pp. 1-29.

Callophis bivirgatus: Günther, Reptiles of British India, 1864, p. 348.

Doliophis bivirgatus: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 400-401; Flower, Proc. Zool. Soc. London, 1896, p. 895; *ibid.*, 1899, p. 692; Boulenger, A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore, including the adjacent islands; Reptilia and Batrachia, 1912, pp. 205-206, fig. 61; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 251-252, fig. 95 (*part.*); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, May, 1923, p. 60.

Maticora bivirgata: Sworder, Singapore Nat., no. 2, 1922, p. 72; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 68; Tweedie, Snakes of Malaya, 1954, pp. 94-95.

Elaps flaviceps Cantor, Proc. Zool. Soc. London 1839, p. 33 (type-locality "Malacca," Malaya); Barbour, Proc. New England Zool. Club, vol. 5, 1914, p. 92 (placed as a synonym of *bivirgatus*).

Doliophis flaviceps: Girard, Proc. Acad. Nat. Sci. Philadelphia, 1857, p. 182.

Adeniophis flaviceps: Meyer, Sitzb. Akad. Wiss. Berlin, 1886, pp. 612, 614.

Calliophis flaviceps: Modigliani, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, vol. 27, 1889, p. 123.

Doliophis bivirgatus flaviceps: Boettger, Katalog der Reptilian-Sammlung im Museum der Senckenbergischen Naturforschenden Gesellschaft, pt. 2, Schlangen, 1898, p. 123 (*part.*).

Maticora bivirgata flaviceps: Brongersma, Zool. Meded., vol. 30, no. 1, Oct. 28, 1948, pp. 15-21 (literature list).

Diagnosis: Anterior poison-fangs present; scales smooth, in 13 rows, lacking pits; tail rather short; subcaudals double (rarely a few may be single); head, venter and subcaudal regions coral-red except on outer edges of scales which are blue-black; poison-gland extending into body cavity.

Description of species (from No. 34344, Bhetong, Yala province): Rostral visible above as a broad triangle, the scale much broader than high; internasals small, wider than long, narrowed to a point laterally; prefrontals about as wide as long, in contact laterally with posterior nasal and large preocular; frontal hexagonal, a little longer than wide, its length equal to its distance from end of snout, shorter than parietals; nostril large, situated between two nasals; no loreal; preocular large, touching third labial; two small postoculars, lower narrow, elongate; temporals, 1+2, anterior very large; six supralabials, last largest, third and fourth entering orbit; six infralabials; first chinshields a little larger than second pair, touching four labials. Eye diameter a little less than distance of eye from edge of lip.

Scale-formula: 17 (occiput), 13, 13, 13; ventrals, 294; subcaudals, 52; anal, single.

Color in life: Head coral-red, color extending back on sides of neck behind mouth-angle; chin lighter; some bluish-black color narrowly surrounds eye; body blackish blue above, each scale somewhat lighter at edges; skin between scales grayish; a narrow grayish ultramarine line on edges of two outer scalerows extending entire length of body from level of sixth ventral. A narrow dark line reaches between parietals to frontal; median part of dorsal surface of tail with a dark blue stripe; subcaudal region coral-red; venter red except outer edges of ventrals which are bluish black; scales more or less iridescent.

Measurements in mm. (Nos. 34344 ♂ and 34345 ♀): Snout to vent, 1195, 619; tail, 144, 76; total length, 1339, 695; width of head, 14, 10; length of head, 19, 15; width of body (greatest), 15, 10.2.

Variation: Specimens of *flaviceps* from Sumatra have a ventral-subcaudal count usually distinctly less than those from the Malay peninsula. Available counts for males for Malaya show the ventral-subcaudal counts vary between 326 and 346.

The sex-difference for a male and female taken at Bhetong, Yala, Thailand, is striking. The male has a total ventral-subcaudal count of 346, the female a count of 298—a difference of 48 scales! Color variation in Thai specimens is almost negligible.

Distribution: This snake is to be found in southern Thailand but records are wanting for localities elsewhere in the country. It has been taken at "Jalor," Pattani; Yala; Narathiwat, Narathiwat (Bangnara); and Singgora (=Songkhla).

The species is known also in Burma, and in Malaya. It is said to be common in certain hill districts in Malaya. A record for Cochin China has been questioned.

Remarks: Little is known regarding the habits of this brilliantly colored species, presumed to be deadly poisonous, but reputed to be unaggressive and rarely attempting to bite. It is known to feed on other snakes. It reaches a known length of 1810 millimeters.

While collecting on Fraser's Hill in Malaya I unexpectedly came upon one under a rock, where I had chased a *Mabuya.* As I lifted the rock the snake suddenly emerged, its teeth becoming caught in my sleeve at the wrist, from where it writhed and twisted as I tried to shake it loose.

The native Malay name in southern Thailand is *Ular sina matahari* (the sun-ray snake). The Thai equivalent of this name is usually applied in northern Thailand to the species, *Xenopeltis unicolor,* which has a high iridescence.

This snake is feared in southern Thailand and Malaya. It is reputed to burn a trail through the grass and other vegetation as it crawls about. Its bright red head and venter are probably responsible for such a belief.

Maticora intestinalis (Laurenti)

Aspis intestinalis Laurenti, Specimen medicum exhibens synopsin reptilium emendatum, 1768, p. 106, (type-locality, based on Seba, vol. 2, fig. 7).

Elaps furcatus Schneider, Historiae amphibiorum naturalis et literariae; fasc. secundus, 1801, pp. 303-304, (type-locality not given; perhaps based on Seba, vol. 2, pl. 2, fig. 7).

Maticora lineata Gray, Illustrations of Indian zoology, vol. 2, 1834, pl. 76, fig. 2 (type-locality?).

Elaps intestinalis: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1028.

Elaps tri-lineatus Duméril and Bibron, Erpétologie générale . . . vol. 7, 1854, pp. 1227-1228, (type-locality, Padang, west coast of Sumatra).

Elaps melanotaeniata Bleeker (named by Boulenger, in Catalogue of snakes, vol. 3, a synonym of *nigrotaeniata*? p. 403.

Callophis intestinalis: Günther, The reptiles of British India, 1864, pp. 348-349.

Adeniophis intestinalis: Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, pp. 386-387, (Burma, Malay Peninsula and Archipelago).

Doliophis intestinalis: Boulenger, Catalogue of the snakes of the British Museum, vol. 3, 1896, pp. 401-404; A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore; Reptilia and Batrachia, 1912, p. 206; Flower, Proc. Zool. Soc. London, 1899, p. 693; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 253-254, fig. 96, (5 "varieties" shown).

Maticora intestinalis: Sworder, Singapore Nat., no. 2, 1922, p. 22; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 267; Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 163; Journ. Nat. Hist. Soc. Siam, vol. 6, 1923, p. 60, (Nakhon Si Thammarat); Bull. Raffles Mus., no. 3, 1930, p. 69; Tweedie, Snakes of Malaya 1954, pp. 95-96; Wegner, Pengemar Alam, vol. 34, 1-2, 1954, pp. 55-58, 2 figs. (not seen).

Doliophis intestinalis var. *annectens* Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 402, (type-locality Singapore and Labuan. Here restricted to the former locality).

Doliophis intestinalis everetti Boulenger, *ibid.*, p. 404, (type-locality, Kina Balu, North Borneo).

Doliophis intestinalis vertebralis Werner, Zool. Jahrb. Syst., vol. 13, 1900, p. 491 (type-locality, Sumatra).

Elaps thepassi Bleeker, Nat. Tijdschr. Nederland Indië, vol. 22, 1859, p. 201 (type-locality, Sintang, Borneo).

Elaps Sumatranus Lidth de Jeude, in Weber, Zool. Ergebnisse, vol. 1, 1890, p. 1 (type-locality, Sumatra).

Callophis furcatus var. *nigrotaeniatus* Peters Monatsb. K. Akad. Wiss. Berlin, 1863, p. 404, (type-locality, Kepahiang, Sumatra).

Callophis intestinalis var. *malayana* Günther, The reptiles of British India, 1864, p. 349 (type-locality, Malayan peninsula "Pinang," Singapore, Central India (Malwali) here restricted to Penang, Malaya).

Callophis intestinalis suluensis Steindachner, Sitzb. Akad. Wien, vol. 100, 1891, pp. 293-295 (type-locality, Sulu Islands).

Doliophis intestinalis immaculata Loveridge, Proc. Biol. Soc. Washington, vol. 57, 1944, pp. 105-106 (type-locality, Marudi, Baram River, Sarawak, Borneo).

Maticora intestinalis intestinalis (Laurenti)

(Fig. 91)

Diagnosis: A small snake (580 mm.) with elongate poison-gland extending into and occupying space in anterior third of body. Scales smooth, without pits, in 13 rows. Body with seven yellowish and eight black longitudinal lines; venter barred with black and greenish yellow; subcaudal region coral-red, with one or two black bars; subcaudals divided; anal single.

Description of species (from No. 34428 ♀, Na Pradoo, Pattani province Thailand): Rostral narrowly visible above, as high as wide; internasals half as large as prefrontals, terminating laterally in a point; prefrontals relatively large; frontal a little longer than wide, longer than its distance from tip of snout, shorter than parietals; supraoculars less than half width of frontal; nostril large, between two nasals, anterior much the larger; no loreal; one preocular, two postoculars; six supralabials, third and fourth entering orbit, (seven on left side due to an intercalated scale between fourth and fifth); temporals, 1 + 2, anterior largest, touching both postoculars; eye diameter less than its distance from mouth; six infralabials, last two largely concealed by last supralabial; four labials touch anterior pair of chinshields which are not or scarcely larger than second pair.

Scales in 13 rows throughout body; across occiput there are 17. No keels or apical pits present. Ventrals, 240; subcaudals, 24; anal, single.

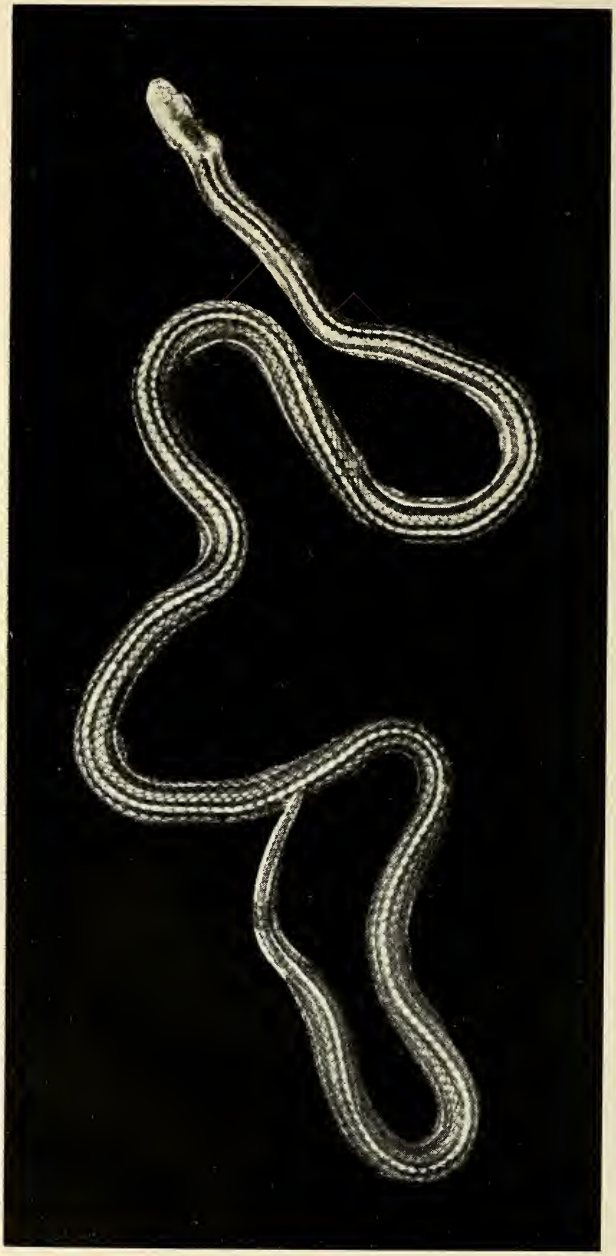

FIG. 91. *Maticora intestinalis intestinalis* (Laurenti). No. 34428 ♀, Na Pradoo, Pattani province. Actual total length, 343 mm.

Color in life: Head variegated black and brown, with some indefinite pinkish spots on prefrontals; labials olive with blackish flecks; median dorsal scalerow rosy, each scale with a coral-red chevron in its latter half; on tail median row drops out and there is a zigzag line of coral between two enlarged median scalerows on tail; median dorsal line bordered on each side with a black line one and a half scales wide, below which is a yellowish-brown line comprising one scalerow and adjoining edges; below this another black stripe, bordered by a cream line between two outer scalerows; outermost row black. Thus eleven stripes are evident.

Tip of chin gray-black; remainder of chin and throat whitish for half an inch, followed on venter by 39 black quadrangular bars separated by an equal number of greenish-yellow bars; subcaudal region coral-red, with a single incomplete dark bar.

Measurements in mm.: Snout to vent, 343; tail, 23; total length, 366; width of head, 5; length of head, 8; width of body, 5.5.

Variation: A second specimen examined in the private collection of Nai Prayoon Kananuracks has the following characteristics: The specimen is faded but agrees generally in color and pattern with the specimen described. Ventrals, 234 ♂; subcaudals, 24; anal, single. There are 35 black ventral bars on body, with one distinct bar on tail. The length in mm. is 446 ± (the specimen coiled and difficult to straighten); width of body, 8 mm.; width of head, 7; length of head, 9.5.

The close agreement between this male and the described female specimen is noteworthy.

One judges by the literature that *Elaps intestinalis thepassi* Bleeker and *Callophis intestinalis malayanus* Günther are synonyms of this form.

Distribution: In Thailand this form is known in Pattani and Yala. Outside of Thailand it has been reported in Malaya and Borneo.

Remarks: The species when disturbed will turn on its back, showing the brilliant ventral coloration, then flop about erratically, sometimes actually throwing its body from the earth. I have not seen it attempt to bite.

The described individual was routed from a small termite-riddled piece of a log in a grove of rubber trees.

Genus *Calliophis* Gray

Calliophis Gray, Illustrations of Indian Zoology, vol. 2, 1834, p. 86, fig. 1 (type of genus, *Calliophis gracilis*).

Diagnosis: Body rather cylindrical, elongate, not tapering posteriorly; tail short; scales smooth; no apical pits; scales in 13 or 15 rows; subcaudals paired. Head not distinct from neck, head-scales normal except loreal absent; nasal divided; eye small with round pupil; poison-fangs followed by from one to five small maxillary teeth (or none in *gracilis* and *macclellandii*).

Malcolm Smith has united the genera *Hemibungarus* with *Calliophis,* the wisdom of which may be questioned. The type species of the latter has no small maxillary teeth behind the large grooved fang. *Hemibungarus* has small maxillary teeth in varying numbers so placed. It would appear that the presence of teeth other than the fangs might be regarded as a generic character. A review of this matter is to be desired. I have made no change in Smith's arrangement since sufficient materials are not at hand for such a task.

Five forms are known in Thailand.

KEY TO SPECIES AND SUBSPECIES OF *Calliophis* IN THAILAND

1. Temporals 1 + 1, the anterior touching two supralabials; no maxillary teeth present behind the enlarged fangs 2
   Temporals one, the anterior touching three supralabials 3
2. Ventrals 182 to 224, subcaudals 21 to 31 ..... *m. macclellandii*
   Ventrals 303 to 320; subcaudals 21 to 28 ..... *gracilis*
3. Ventral shields, 174-203; subcaudals, 21-31 4
   Ventral shields, 285; coloration uniform without line or spots on body; blue under tail ..... *hughi*
4. Light brown with a median vertebral black line and lacking black spots on the body; ventrals, 184±; (*univirgatus* not of Günther) ..*m. malcolmi*
   Light brown with small or larger distant black spots, usually paired, larger and smaller ones alternating; head black with paired yellow spots; two black rings on tail, gray or blue on underside; ventrals, 174 to 203, *m. maculiceps*

Calliophis macclellandii macclellandii (Reinhardt)

(Fig. 92)

Elaps macclellandii Reinhardt, Calcutta Journ. Nat. Hist., vol. 4, 1844, p. 532 (type-locality, Assam); Vidensk, Medd. Naturh. Foren. Kjöbenh, 1860, p. 247.

Callophis macclellandii: Günther, Proc. Zool. Soc. London, 1861, p. 218; Reptiles of British India, 1864, pp. 349-350; Boulenger, The fauna of British India, including Ceylon and Burma, Reptilia and Batrachia, 1890, p. 385; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 327; Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 398-399; Acton and Knowles, Indian Journ. Med. Res., vol. 2, 1914, p. 56; Annandale, Rec. Ind. Mus., vol. 8, 1912, p. 50; Sclater, List of the snakes in the Indian Museum, Calcutta, 1891, p. 56; Venning, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910, p. 342; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1901, p. 612; *ibid.,* vol. 18, 1908, pp. 333 and 780; vol. 19, 1909, p. 356; and vol. 22, 1913, p. 639; vol. 25, 1918, p. 628, colored pl. and

vol. 31, 1926, p. 566; Poisonous snakes of India, 1928, p. 31, fig.; Pope, Reptiles of China, 1935, p. 406, fig.; M. Smith, Fauna of British India, including Ceyon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 423-425, fig. 135.

Elaps personatus Blyth, Jour. Asiat. Soc. Bengal, vol. 23, 1855, p. 298 (type-locality, Assam).

Callophis annularis Günther, Reptiles of British India, 1864, p. 350, pl. 24, fig. I (or J) (type-locality, "India").

Diagnosis: A relatively small snake (812 mm.). Body cylindrical, head scarcely distinct from neck; scales in 13 rows; preocular separated from nasal. Temporals, 1 + 1, the anterior shield touching two labials; seven supralabials. Reddish or red-brown above, with regular transverse narrow black bands or bars which may not reach belly; head largely black above with a broad cream band across head behind eyes; yellowish below with black bands or bars covering one to four ventrals. Tail short, ringed with several black bands. A large fang but no other teeth on maxillary; anal normally divided.

Description of species (from No. 33637, Doi Suthep, Chiang Mai): Rostral wider than high, only narrowly visible above; internasals broader than long; prefrontals larger than internasals, broader than frontal; latter scale longer than its distance from snout, shorter than parietals; supraoculars more than half width of frontal; nostril between two nasals; but chiefly in anterior; suture below nostril passing to second labial; no loreal; large preocular touching posterior nasal, separating labials from prefrontal; two postoculars, both touching first temporal; temporals, 1 + 1 + 2; first touching fifth and sixth supralabials; seven supralabials, third and fourth border orbit; six infralabials, four touching anterior chinshields, which are larger than second pair.

Scalerows: 15 (occiput), 13, 13, 13; scales smooth, outer row largest, all lacking pits; ventrals, 207; subcaudals (paired), 33; anal, divided.

Color in life: Body reddish above (red-brown in preservative); venter yellowish to saffron with 24 narrow black bands around body, one, to one and one-half scalerows in width some broken ventrolaterally; tail with five rings, and two black spots on subcaudal area between rings; on venter, black spots covering from two to four ventrals; many body bands are broken low on side; head black, tip of snout lighter; snout and part of frontal area dark; a broad ivory-white band behind eyes, anterior border convex, posterior border undulating, followed by a broad black band;

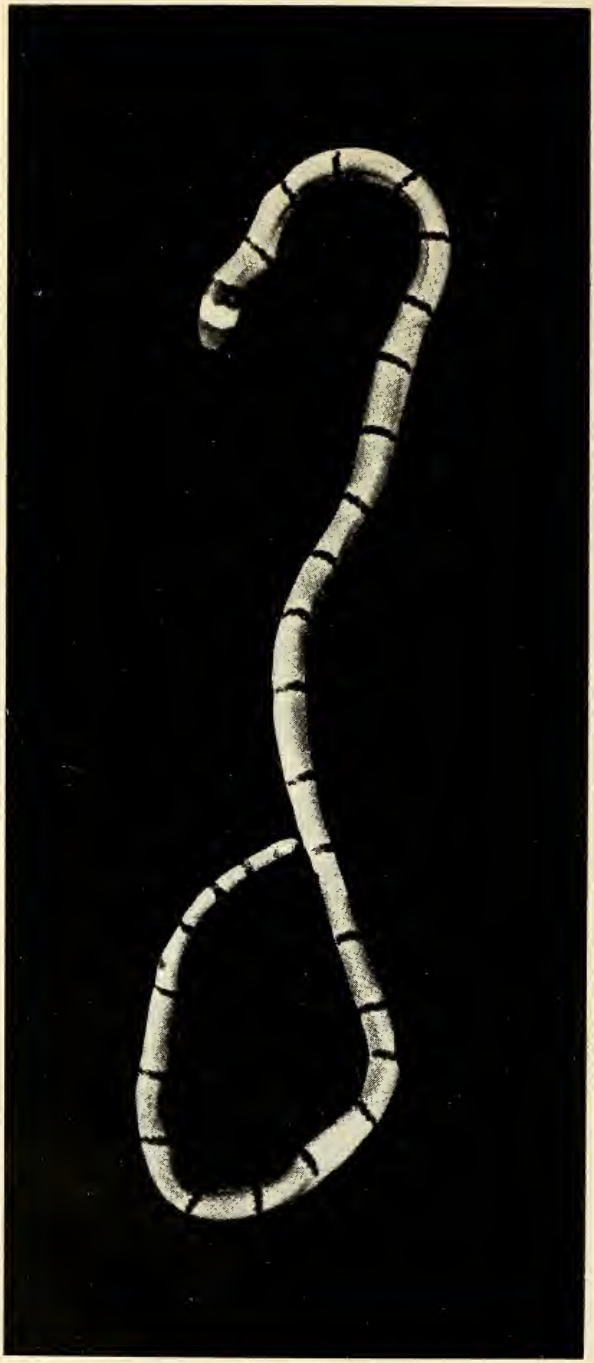

FIG. 92. *Calliophis macclellandii maclellandii* (Reinhardt). No. 33637 ♂, Doi Suthep, Chiang Mai, Thailand. Actual length, 266 mm.; tail, 26 mm.

which in turn is followed by a fine yellowish line; chin yellowish white with a dim median dark spot; venter yellowish with black cross-bars or spots.

Measurements in mm.: Total length, 266; snout to vent, 240; tail, 26; head-width, 4.8; head-length, 9; body-width, 5.

Variation: Malcolm Smith has placed several forms (*m. univirgatus, m. nigriventer, m. gorei* and *m. concolor*) as synonyms. It seems likely that some of these may represent related species or subspecies.

The specimen of the typical form figured by Wall (1918) and that by Malcolm Smith (1943) differ slightly, from the described specimen. The nuchal black bar forms a mesial angle anteriorly that almost touches the frontal and extends back on neck covering most of three scalerows. In my specimen the black band has two salient points on the parietals rather than a single mesial one.

The ventrals vary between 182 and 240; subcaudals, 20 and 36 pairs. The number of rings encircling the body varies from 16 to 35; the caudal bands from two to five in Indian specimens.

Distribution: The distribution of the so-called color variants is as follows: a form *nigriventer*, western Himalayas; *univirgatus*, Nepal and eastern Himalayas; *gorei*, Naga Hills in Assam and Manipur; and *m. macclellandii*, Assam, Burma, Formosa, and China.

This is probably the first and only report of the species in Thailand. A second specimen (EHT-HMS No. 36538, is a gift from Mr. Oliver Gordon Young. The snake was collected on Doi Suthep near Chiang Mai. There are 29 rings about the body, each about the width of one scale; four rings on tail. Only an occasional ring is broken ventrolaterally. The tail ends in a semirigid spine. The ventrals are 228; the subcaudals, 30; the anal is divided.

Calliophis gracilis Gray

Calliophis gracilis Gray, Illustrations of Indian Zoology, vol. 2, 1834, pl. 86, fig. 1 (type-locality, Penang Island, Malaya).

Callophis gracilis: Günther, Proc. Zool. Soc. London, 1859, p. 83; Reptiles of British India, 1864, p. 349 (remarks that the figure of dentition given by Gray is incorrect); Peters, Monatsb. K. Akad. Wiss. Berlin, 1871, p. 579; Meyer, Sitzungsb. Akad. Wiss. Berlin, 1886 p. 614; Boulenger, Catalogue of the snakes in the British Museum 2nd Ed. vol. 3, 1896, pp. 396-397 (Penang, Singapore and Sumatra); A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 203-204; Sworder, Singapore Nat., no. 2, 1922, p. 72 (Singapore); M. Smith, Bull. Raffles Museum, no. 3, 1930, p. 68; Tweedie, The snakes of Malaya, 1954, p. 93.

Elaps nigrocinctus Cantor, Proc. Zool. Soc. London, 1839, p. 33 (type-locality, Singapore; Catalogue of Malayan Reptiles 1847, p. 108, pl. 40, fig. 7.

Elaps gracilis: Günther, Catalogue of the Snakes in the British Museum, 1858, p. 230.

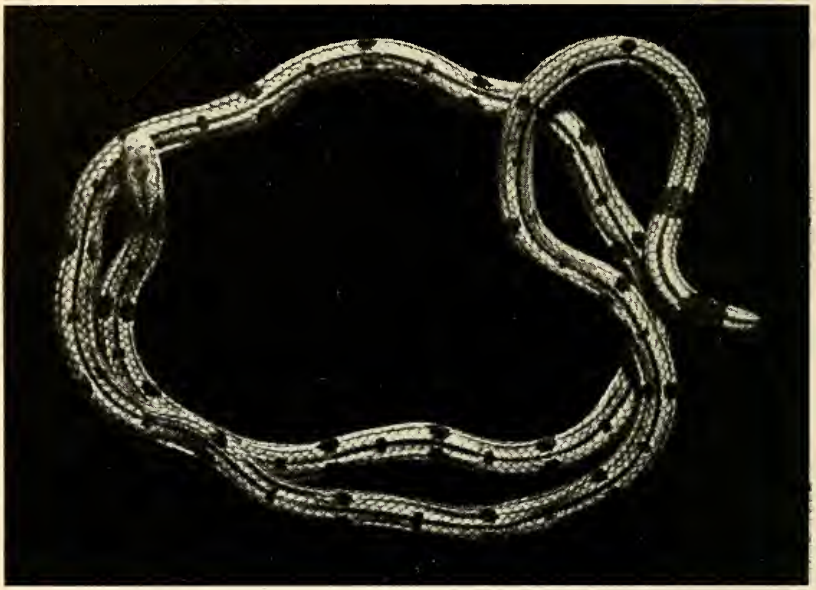

FIG. 93. *Calliophis gracilis* Gray. C.U. No. 3170, Na Pradoo, Pattani, province, southern Thailand. Actual total length, 355 mm.; tail, 21 mm.

Diagnosis: A very slender gray snake with a narrow median black line and four lateral black lines. A pair of large nuchal spots followed by a paired series of 25, rounded dorsolateral spots on body, each covering four or five scales; at intervals between pairs a single series of smaller spots interrupts the median black line; tail with two wider complete bands; tail ending bluntly in a large rounded black scale. Venter barred with 50 deep black spots separated by somewhat larger ivory-white bars; under tail the ivory-white spaces are wider; laterally on tail only two black stripes.

Description of species (from no. 3107, Na Pradoo, Pattani): Body slender, the width in length about 89 times; head distinctly flat above; tail ending bluntly. Rostral about as high as wide, the part visible above, triangular; internasals distinctly smaller than prefrontals, wider than long, pointed laterally; prefrontals relatively large, nearly as large in area as frontal; frontal a little longer than wide, shorter than its distance to tip of snout, much shorter than parietals; supraoculars about four-fifths as wide as frontal; parietals elongate, their length equal to their distance from tip of snout; nasal divided, anterior part much the larger; a preocular diagonally elongated; two postoculars, both touching the very

large single anterior temporal; temporals, 1+1+1; parietals sharply truncate, followed by two scales larger than body-scales; six supralabials, first smallest, last largest, third and fourth bordering orbit; mental nearly triangular, its labial border equal to rostral border; first infralabials in contact; first pair of chinshields as long as, but wider than, second pair; seven infralabials, fourth largest, first four border first chinshield. Scale-formula: 20 (occiput), 13, 13, 13; no apical pits; around tail near base, eight scales; at terminus, six. Ventrals, 306; anal, divided; subcaudals, 28, paired.

Color: Color gray to brownish gray, lighter on sides and lower down nearly white. A narrow median black stripe from head to tip of tail, not entirely covering median scalerow, the borders straight; it bifurcates anteriorly sending two short arms on parietals; this stripe bordered by a grayish one covering one whole scalerow and edges of the median row and more than half of a second row; a brownish black stripe on edges of fourth and fifth scalerows arising from black nuchal spots and continuing to tip of tail; upper edges of third scalerow brownish gray, the middle with whitish dashes, lower part deep black; first and second rows deep black, each scale with a white dash which, together with those on third row, form three dashed white lines. On tail only a single continuous white line bordered by black lines. A pair of large lateral nuchal spots followed by a series of 25 lateral paired spots terminating at vent, and a median series of somewhat smaller spots interrupting median line. Larger lateral spots covering four or five scales, smaller median spots one or two scales. Venter with chin and part of throat flecked with gray-black; front of neck ivory.

Transverse black bars begin at about 9th ventral and continue to tail, 51 in all. At first one or two ventrals are covered, but the spots cover three ventrals for the most part; the intervening ivory to cream-white spots cover three ventrals (rarely four); undersurface of tail ivory with two bands encircling tail. Terminal caudal scale black, rounded. An irregular light stripe on supralabials partly edged with black; anterior head scales with darker areas. A distinct black bar from eye to temporal region.

Measurements in mm: Total length, 355; tail, 21; width of head, 3.8; length of head, 6.1; width of body, 4; width of body in total length, about 89 times.

Remarks: This presumably is the first record of this species in Thailand. It probably reaches but a short distance into the country. The obvious differences between this species and *C. maculiceps* are such that there is small likelihood that they could be confused.

Calliophis hughi Cochran

Callophis hughi Cochran, Proc. Biol. Soc. Washington, vol. 40, Dec. 2, 1927, pp. 190-191 (type-locality, Koh Tao, Gulf of Siam); Proc. U. S. Nat. Mus., vol. 77, 1930, p. 37, fig. 6; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 421.

Diagnosis: One pre- and two postoculars; seven upper labials; ventrals, 285; a single temporal; body immaculate reddish-brown above, extreme edges of each scale powdered with minute gray dots.

Description of species (from type-description): Rostral broader than deep; internasals smaller than prefrontals, their common suture about half of that between prefrontals; frontal with sides nearly parallel, distinctly broader than supraocular, as long as its distance from end of snout, much shorter than parietals; nasal divided; a preocular entering upper anterior part of orbit, and two postoculars, both touching anterior temporal; temporals, 1 + 2; seven supralabials, third and fourth border orbit; infralabials eight, four touching first chinshield (however the second is excluded); second chinshield smaller than first.

Scalerows: 13, 13, 13; ventrals, 285; subcaudals, 27; anal, divided.

Color: Body above nearly uniform immaculate reddish brown, scale-edges with gray pigment; anterior part of venter cream, becoming pink posteriorly. At base of tail a complete black ring; then four irregular spots on undersurface of tail and near the tip another black ring which is not complete above; the top of head entirely black excepting for outermost portions of parietal region and outer halves of internasal plates, which are light brown. The black nuchal mark does not completely surround the neck, but covers the nape and ends below the commissure of the mouth. Sutures between anterior labials of upper and lower jaw are marked by black, the most decided mark coming between third and fourth labials; behind this point labials entirely white.

Measurements in mm.: Total length, 260; tail, 26.

Remarks: Dr. Cochran states that its nearest relative is *C. maculiceps,* that it has a much lower number of ventrals, and that dots or spots are absent on back. An island form known only from the type.

Calliophis maculiceps Günther

There are two or three varieties of this species found in Thailand. The material available does not permit the recognition of more than two subspecies. Certain of the variants are figured.

Calliophis maculiceps maculiceps Günther

(Figs. 94, 95, 96)

Elaps maculiceps Günther, Catalogue of the colubrine snakes in the British Museum, 1859, p. 232 (type-locality, "East Indies"); Theobald, Journ. Linn. Soc., vol. 10, Zoology, 1868, p. 62.

Callophis maculiceps: Günther, Proc. Zool. Soc. London, 1859, p. 84, pl. 16, fig. D; The reptiles of British India, 1864, p. 351; Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 384; Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 397-398; Laidlaw, Proc. Zool. Soc. London, 1901, pt. 2, p. 580; Boulenger, A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore; Reptilia and Batrachia, 1912, p. 204; Wall and Evans, Journ. Bombay Nat. Hist. Soc., vol. 13, 1900, p. 344; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, pt. 3, Mar., 1915, p. 214; Gyldenstolpe, Küngl. Sven. Vet-Akad., vol. 55, 1916, pt. 3, p. 26; Wall, Journ. Bombay Nat. Hist. Soc., vol. 30, 1925, p. 244; The poisonous snakes of India, 1928, p. 31, fig.; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, pt. 2, 1914, pp. 123-124 (varieties); M. Smith, Bull. Raffles Mus., Singapore, no. 3, Apr., 1930, p. 68 (Khao Ronpibun, Nakhon Si Thammarat); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, May, 1923, p. 59; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 37; Bourret, Les serpents de l'Indochine, 1936, p. 403; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 420-421.

Elaps melanurus: Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1027, pl. 40, fig. 6 (not of Shaw).

Elaps atrofrontalis Sauvage, Bull. Soc. Phil. Paris, ser. 7, vol. 1, 1877, p. 111 (type-locality, Cochin China).

Diagnosis: A small slender snake reaching a length of little more than half a meter; one preocular, two postoculars; seven supralabials; one temporal, touching three labials; one preocular touching nasal; scales in 13 rows.

Reddish or gray-brown with paired dark spots on each side, between which are smaller pairs; two black bands encircle tail; belly pink; subcaudal region blue with black spots.

Description of species (from specimen 1, Royal Forest Department, Ban Na Kom, Khao Luang): Rostral a little wider than high, well visible above; internasals slightly wider than long, angular anteriorly; prefrontals little wider than long, nearly double area of internasals, forming an angle on side; frontal hexagonal with sides parallel, its length slightly less than its distance from tip of snout, less than its distance from end of parietal; parietals rather large, their tips separated posteriorly by a scale; two nasals, anterior larger; one preocular, touching posterior nasal, separating prefrontals from labials; two postoculars, both touching temporal; anterior temporal very large, broadly in contact with three posterior supralabials; seven supralabials, first smallest, last largest, third and fourth bordering orbit; eye moderate, its diameter slightly

FIG. 94. *Calliophis maculiceps maculiceps* (Günther). No. 34216, Bang Saen, Chon Buri, Thailand. Actual total length, 305 mm.; tail, 32 mm.

less than its distance from mouth; secondary temporal large, bordering parietal, separated from its fellow by three scales behind parietals. Mental triangular; first chinshields a little larger than second pair, and bordered by five infralabials; seven infralabials; an enlarged scale touching second chinshield and last three infralabials.

Scale formula: (♂) 17 (head), 13, 13, 13; scales smooth, without pits. Ventrals, 198, anal, divided, subcaudals, 30, paired (except terminal one).

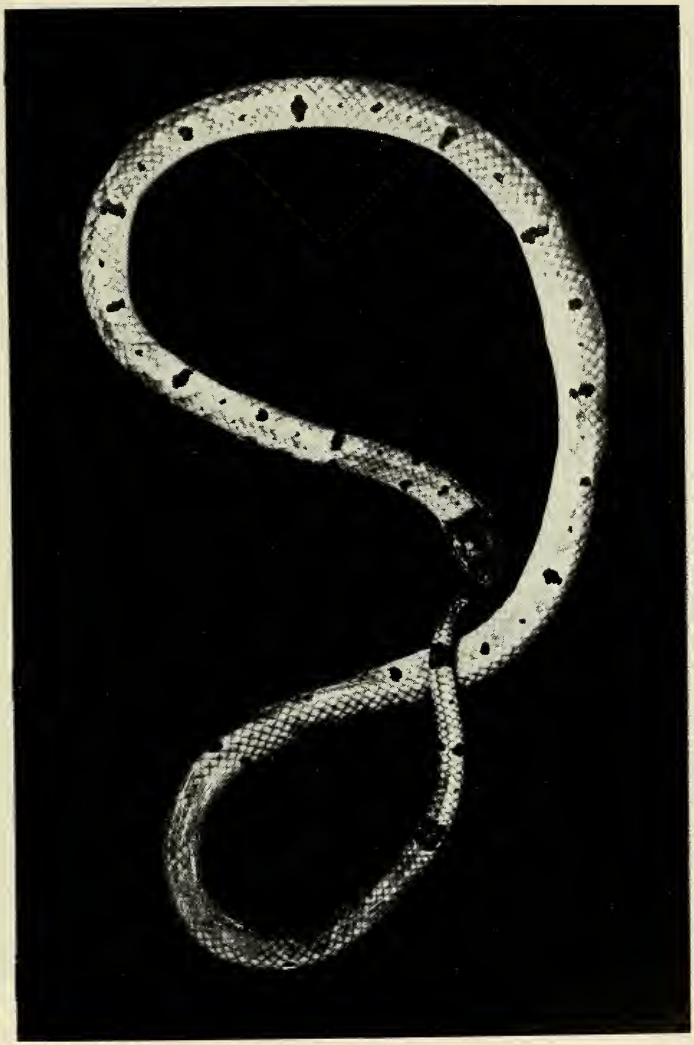

FIG. 95. *Calliophis maculiceps maculiceps* Günther. No. 1, Royal forest department, Khao Luang, Thailand. Actual total length, 318 mm.; tail, 33 mm.

Color: Head rather dark olive anteriorly with inconspicuous lighter areas on scales of snout; a black bar, three or four scales wide, across occiput, with a median process reaching frontal. Lighter areas on parietals and second temporal; whitish spot covering last three supralabials and part of first temporal; body above brown, growing lighter laterally and gradually becoming pink below; black spot on neck truncate behind; paired lateral

FIG. 96. *Calliophis maculiceps maculiceps* (Günther). No. 3869 Na Pradoo, Na Pradoo, Pattani, Thailand. Enlarged somewhat.

spots somewhat lighter-edged extending length of body with smaller black dots intercalated; two black bands surround tail, the first narrowed below; venter, from chin to vent, reddish or pink; subcaudal region gray-blue with numerous black flecks.

Measurements in mm. (two specimens from same locality, Khao Luang): Snout to vent, 318, 308; tail, 33, 33; total length, 351, 341; head-width, 6, 6; head-length, 9.2, 8.8.

Variation: The second specimen measured above, has 201 ventrals, and 30 subcaudals; the color and marking are almost identical with the preceding.

Remarks: The specimen described contained a partially digested *Typhlops,* of which the anterior part of the body and head were missing, while the posterior part was in a fair state of preservation. This part was black above, white below, with 24 scalerows present around the body. The tail is white, the colors in strong contrast. The diameter of the body is 4.1 mm. The undigested portion measures 83 mm. in length. I cannot identify the *Typhlops* with species known from Thailand.

Theobald (1868) records the markings of a specimen from Rangoon as follows: Uniform pale brown with a chain of 36 distant, not very distinct black dots down each side. Crown of head black, giving off a broad streak behind eye and uniting with a black collar on the nape. A subterminal black ring on tail and a broader one at the base expanded above into a rhomboidal escutcheon, with a median line down the tail on its dorsal surface.

Two specimens are available from Na Pradoo, Pattani. Each has 197 ventrals and 27-28 subcaudals, the tails ending in a sharp pointed spine tending to turn down.

A figured specimen (Fig. No. 34216), has the smallest spots of any specimen examined. I captured it at Bang Saen from under the bark of a small log. The colors of the living specimen were reddish-pink above with paired or alternating fine black dots on sides. A rather large rhomboidal black spot formed a band around the base of the tail; a small spot near the tip. Below, dirty white on chin and at beginning of throat, then gradually becoming pinkish and later orange. Near the tail tip the orange

Table of data on *Calliophis maculiceps maculiceps* Günther

NUMBER	Sex	Locality	Ventrals	Subcaudals
102985	♀	Chiang Mai	199	26
33636	♀	Chiang Mai	198	28
70331	♀	Nong Khai	192	21
24027	♀	Trang	192	29
1427	♀	Na Pradoo	196	27
101519	♂	Chiang Mai	185	32
3869	♂	Na Pradoo	184½	30
34216	♂	Bang Saen	177	29
812	♂	Loc. uncertain	198	30

is intense. It is white under the tail, the head an intense black above, the sides with some cream or whitish spots connecting with color under chin. Some black and yellow flecks are present on front of chin.

Calliophis maculiceps malcolmi nov. nom.

(Fig. 97)

Callophis maculiceps univirgatus, M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, Aug. 1914, p. 123 (type-locality Nong Kai Ploi, Thailand) not *Elaps univirgatus* (Günther) 1859; Journ. Bombay, Nat. Hist. Soc., vol. 23, May 25, 1915, pp. 786-787.

Diagnosis: Yellowish brown with a conspicuous black vertebral line running whole length of body and tail.

Description of species (from No. 33197 near Sara Buri, Sara Buri province, Central Thailand *): Rostral broader than high, the part visible above triangular; internasals less than half area of prefrontals their mutual suture about half that of prefrontals; frontal with sides parallel, length equal or slightly greater than its distance from tip of snout; nasal divided, nostril almost wholly in anterior nasal which is larger than posterior part; a preocular, two postoculars; temporals destroyed; labials and part of lower jaw missing.

Scalerows: 13, 13, 13, smooth without apical pits; ventrals, 184±, subcaudals, 21; anal, divided; upper jaw bearing two grooved fangs followed by a diastema, and this followed by three small teeth; on lower jaw, two larger mandibular teeth followed by a diastema and this by six small teeth.

Color in life: Olive above; below coral pink on venter, for two or three centimeters in front of tail, deep tomato-red. A sharply distinct median black stripe from head to tip of tail. A black band at base of tail wider dorsally than ventrally; a second black band near tip; subcaudal area deep blue-black with some bluish-white spots. Dorsum and sides generally olive with a sharply marked median black line covering most of the median scalerow and a mere part of the edges of adjoining rows; A blackish band on neck and occiput; venter pinkish anteriorly changing to rosy pink then to tomato-red preceding vent. Top of head with some darker and lighter markings, the spotting not distinct.

The color in preservative is lavender brown, the scale-centers light fawn or dull cream; venter white.

Measurements in mm.: Total length, 306 ±; tail 24 ±.

* This specimen captured within two hundred meters of Friendship Highway in an open field near buildings, was taken alive and kept for several days. While being photographed the specimen was stepped on and killed, destroying a part of the head. Such characters as are apparent are recorded.

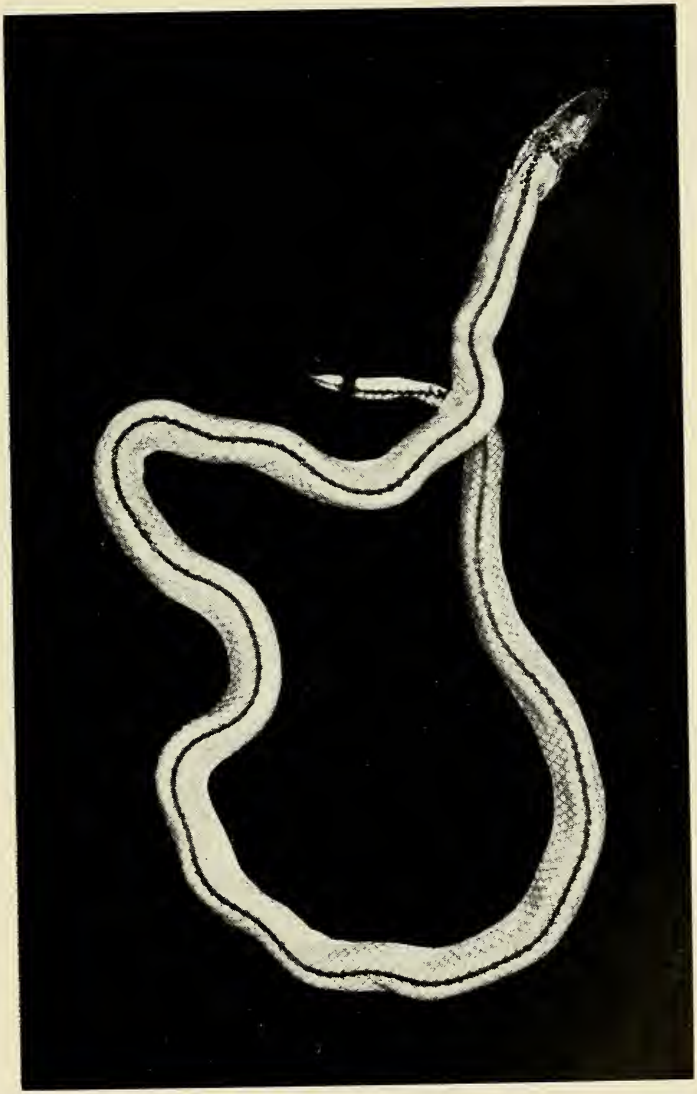

FIG. 97. *Calliophis maculiceps malcolmi* nov. nom. No. 33197, near Sara Buri, Sara Buri province, Thailand. Actual total length, approximately 306 mm. ±; tail, 24 mm. ±.

Distribution: Known only from central and southeastern Thailand. The described specimen is from Sara Buri province.

FAMILY HYDROPHIIDAE

Hydrophidae Boie, Isis, 1827, p. 410.

Diagnosis: Body more or less compressed, tail strongly compressed and vertically widened. Nostrils on dorsal surface of snout except in Laticaudinae; pupil round; tongue short, only cleft portion extrusible. Poison-glands and fangs present on maxillary followed by ungrooved maxillary teeth; neural spines and hypapophyses strongly developed in caudal region.

Two subfamilies are recognized and may be differentiated by the following key:

KEY TO SUBFAMILIES OF HYDROPHIIDAE

1. Maxillary bone extending forwards beyond palatine; ventrals large, one third to more than half width of body. Snake capable of crawling on land and spending considerable time out of the water..... *Laticaudinae*
2. Maxillary bone not extending forwards beyond the palatine except in *Kerilia* and *Microcephalophis*; ventrals small not more than one-fourth the width of body, or very small or absent; snakes practically unable to crawl on land..... *Hydrophiinae*

Subfamily LATICAUDINAE

Representatives of two genera belonging to this subfamily are found in Thai waters; they may be differentiated as follows:

KEY TO THE THAI GENERA OF THE LATICAUDINAE

Nostril lateral, nasals separated by internasal (single or divided)..... *Laticauda*
Nostrils on top of snout, nasals in contact with one another..... *Aipysurus*

Genus *Laticauda* Laurenti

Laticauda Laurenti, Specimen medicum exhibens synopsin, reptilium emendatum, 1768, p. 109 (type of genus *L. scutata*, substitute name for *C. laticaudatus* of Linnaeus).

Platurus Latreille, Histoire Naturelle des Reptiles, vol. 4, 102, p. 183, (type of genus *P. fasciatus* = *laticaudata*); Boulenger, Catalogue of the snakes in the British Museum, 2d Ed vol. 3, 1896, p. 306.

Diagnosis: Maxillary bone much shorter than ectopterygoid, extending forward beyond palatine; poison-fangs followed after an interval by one or two teeth. Head shields complete, large; nostrils lateral, nasals separated by internasals. Scales smooth, imbricate; ventrals large, half width of body; females larger than males, with shorter tails.

There are four recognized species in this genus, two of which have been reported from waters adjacent to Thailand. These are

Laticauda colubrina and *Laticauda laticaudata*. These forms may be distinguished by the following key:

KEY TO THAI SPECIES OF *Laticauda*

1. Scalerows about body, 19; no azygous shield between prefrontals; upper lip dark brown..... *laticaudata*
   Scalerows about body 21-25; normally an azygous shield between prefrontals; upper lip yellow..... *colubrina*

The snakes of this group are large and at least two species *semifasciata* and *colubrina* are said to be oviparous.

I have seen very large numbers of the serpents identified as *L. colubrina* on the small island of Bubuan, Sulu Archipelago. Here I have observed large females, with large broods of young, presumably born alive.

The species of this genus are able to crawl on land with considerable ease, due to their widened ventrals. They are not aggressive and may be picked up by their tails or otherwise handled with impunity.

Skins of these snakes are sought by skin collectors who find a ready market for them. They are used for the manufacture of leather goods.

Since these snakes tend to be gregarious at certain seasons they often are taken in large quantities. In the Philippines they are protected by the government. The late Dr. Albert W. C. T. Herre studied the ecology of these snakes in the Philippines, and in a report by Herre and Rabor* states "About 1923 the senior author discovered that the Riu Kiu fishermen operating in the Philippines were catching members of *L. semifasciata* and eating them. Those not eaten at once were kept alive in unglazed earthen jars until wanted for food. . . . Some of the fishermen began to make special effort to catch sea-snakes for two purposes: one, to sell their skins for making leather; two, to sell their flesh for food. . . . At the present time the Philippine Bureau of Fisheries controls the taking of snakes at Gato (island). A Filipino concessionaire has been given a monopoly for 20 years. He pays a tax on each kilo of skins ready for shipment."

"Snakes that are eaten by the Japanese are spitted on pointed bamboo. This makes the snake stiff and easy to handle. Most of the snakes are then roasted and smoked, or prepared in the same way as smoked fish. They are usually eaten with soy sauce and various condiments and are then said to be very palatable."

* Herre and Rabor, Copeia, 1949, No. 4, Dec. 15.

Laticauda colubrina (Schneider)

(Fig. 98)

Hydrus colubrinus Schneider Historiae amphibiorum naturalis et literariae, fasc. 1, 1799, pp. 238-240 (type-locality unknown).

Hydrophis colubrinus: Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 514, pl. 18. (*part.*).

Platurus colubrinus: Girard, Herpetology of the U. S. Exploring Expedition, 1858, p. 183; Peters, Monatsb. Akad. Wiss. Berlin, 1877, p. 420; Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed, vol. 3, 1896, pp. 308-309, fig.; A vertebrate fauna of the Malay Peninsula . . .; Reptilia and Batrachia, 1912, p. 197; Boettger, Katalog der Reptilien-Sammlung im Museum der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt am Main, pt. 2, Schlangen; 1898, p. 115; Wall, Mem. Asiat. Soc. Bengal, vol. 2, (8) 1909, p. 186, fig.; Roux, Abh. Senckenb. Ges. Frankfurt, vol. 23, 1910, pp. 223, 243; de Rooij, Reptiles of the Indo-Australian Archipelago 1917, pp. 217-218, fig. 83.

Platurus laticaudatus colubrinus: Peters and Doria, Ann. Mus. Civ. Genova, vol. 13, 1878, p. 412.

Laticauda colubrina: Stejneger, U. S. Nat. Mus. Bull. No. 58, 1907, p. 406; Longman, Mem. Queensland Mus., vol. 6, 1918, p. 41; Wall, Ophidia Taprobanica or the snakes of Ceylon, 1921, p. 431-434, fig. 82; Taylor, Snakes of the Philippine Islands 1922, p. 231; M. Smith, Monograph on the sea-snakes (Hydrophiidae) 1926, pp. 6-10; Smedley and Kloss, Journ. Malay Br. Roy. Asiat. Soc. vol. 4, 1926, p. 1963; M. Smith, Bull. Raffles Mus. No. 3, 1930, p. 71; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3 Serpentes, 1947, pp. 443-444, text figs. 141-142; Brongersma, Zool. Meded., no. 27, 1947, p. 308 (Pulu Bagan, Penang) Malaya; Tweedie, Snakes of Malaya 1954, pp. 102-103, pl. 9, text. fig. 24.

Platurus fasciatus colubrinus: Fischer, Abh. Naturw. Ver. Hamburg, vol. 3, 1856, p. 30.

Laticauda scutata Cantor, Journ. Asiat. Soc. Bengal, vol. 16, pt. 2, 1847, p. 125 (not of Laurenti).

Platurus scutatus: Günther, Reptiles of British India, 1864, p. 356.

Platurus frontalis De Vis, Ann. Queensland Mus., 1905, p. 48 (type-locality Brisbane, Australia).

Diagnosis: Large snakes, grayish above, yellowish below, with black bands, some, or all of which may be incomplete. Body of nearly uniform diameter throughout; prefrontals usually separated by a single scale; scalerows, 21-23 (rarely 25); a double series of elongated scales, the inner series the larger, bordering oral margin following second infralabial. Ventrals widened.

Description of species (EHT-HMS No. M 217 from near Singapore): Body subcylindrical, only slightly compressed. Rostral higher than broad, with a small tonguelike projection below, touching two supralabials, two nasals and two internasals; an azygous shield separating prefrontals; nostril lateral in lower part of undivided nasal; frontal very large, nearly twice as long as its distance from tip to snout, a little longer and with as large an area as a parietal; a somewhat enlarged median scale following parietals,

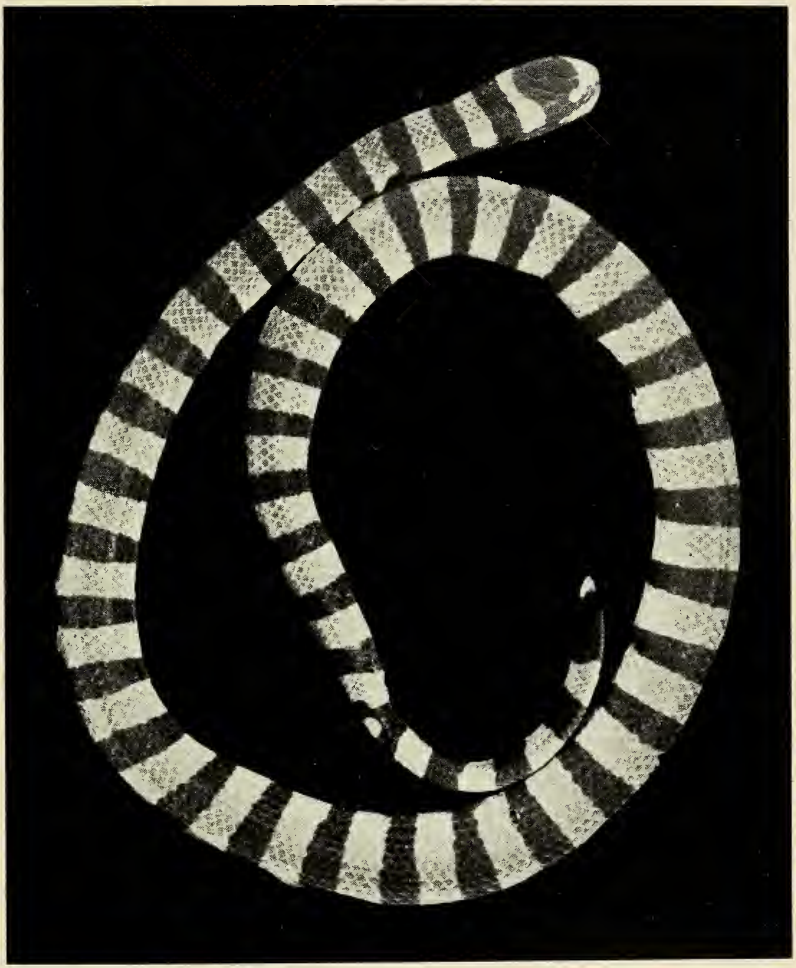

FIG. 98. *Laticauda colubrina* (Schneider). EHT-HMS No. M 217♀, Pulao Biola, near Singapore, J. R. Hendrickson coll. Actual total length, 444 mm.; tail, 54 mm.

which is one of three postparietals between temporals; one preocular, two postoculars; supralabials seven, the third and fourth bordering orbit; temporals, 1 + 2 + 3; infralabials, eight or nine, small, first five border two pairs of chinshields, both of which are well developed, anterior smaller, both pairs in contact with each other; a small azygous scale between anterior pair and first pair of infralabials; a double series of scales on lower oral border posterior to second infralabial, the result of a horizontal segmentation of the scales.

Scalerows: 23 on neck, 23 at middle of body, the scales smooth and imbricate throughout. Ventrals, 243, last, preceding vent, divided, others single, four times as broad as long; anal, divided; subcaudals, 45, paired.

Color in life: Light or dark bluish-gray above, yellowish below with black bands of more or less uniform width throughout, or narrowing on venter, none interrupted below; snout yellow, color extending backwards on each side of head above eyes as far as temporal shields, and along upper lip, leaving a dark bar between. Remainder of head black, color joining with first band crossing occiput, and this frequently connected with two following bands on underside of neck, but leaving a median ventral yellow patch connecting with first light band.

Measurements in mm.: Total length, 444; tail, 54.

Variation: The azygous scale, normally present between the prefrontals, is occasionally absent throughout its range. The most extraordinary variation is in the number of black bands. These vary from 24 (New Caledonia) to 64 in the Philippines. Occasionally a lateral ventral keel occurs, sometimes a median ventral keel on the posterior part of the body. These variations may represent subspecies. Ventrals vary from 213 to 246; The subcaudals in females from 37 to 47; in males, from 27-35.

Distribution: A rare snake in Thailand waters. A single specimen in the Hamburg Museum from "Siam" is, I believe, the only one recorded.

It is widely distributed, elsewhere being known from southern Malaya, Singapore, Calcutta, the Andaman and Nicobar Islands. It also occurs on islands of the South Pacific, coasts of Australia, but is presumably lacking in certain of the islands of the Archipelago. It reaches as far as the Fiji Islands, the Caroline Islands and New Zealand.

It is possible that colonies may be discovered about some of the coastal islands on the east or west coasts of Thailand.

Laticauda laticaudata (Linnaeus)

Coluber laticaudatus Linnaeus, Systema naturae, 10th Ed. 1758, p. 222 (type-locality, India); Andersson, Bihang Sven. Vet. Akad. Handl., 24 pt. 4, 1899, p. 18.

Platurus laticaudatus: Girard, Herpetology of the U. S. exploring expedition, 1858, p. 180; Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed. vol. 3, 1896, pp. 307-308; Boettger, Katalog der Reptilien-Sammlung im Museum der Senckenbergischen Naturforschenden Gesellschaft in Frank-

furt am Main. Teil II, Schlangen, 1898, p. 114; Wall, Mem. Asiat. Soc. Bengal, vol. 2, (8), 1909, p. 185; de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 217; Lord, Proc. Roy. Soc. Tasmania, 1918, p. 81.

Laticauda laticaudata: Stejneger, U. S. Nat. Mus. Bull. 58; (Herpetology of Japan) 1907, p. 402, fig.; Wall, Snakes of Ceylon, 1921, p. 427; Taylor, Snakes of the Philippine Islands, 1922, pp. 228-229.

Laticaudata l. laticaudata: Barbour, Mem. Mus. Comp. Zool. Harvard Col. vol. 44, 1912, p. 131; ? Peters and Doria, Ann, Mus. Civ. Genova, vol. 13, 1878, p. 412.

Laticauda scutata: Laurenti, Specimen medicum, exhibens synopsin reptilium emendatum 1768, p. 109 (substitute name for *laticaudatus.*).

Platurus colubrinus: Peters, Monatsb. Akad. Wiss. Berlin 1877, p. 418.

Platurus fasciatus Latreille, Histoire naturelle des reptiles, vol. 4, 1802 p. 185; Fischer, Abh. Naturw. Ver. Hamburg; vol. 3, 1856, pp. 28, 70; Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 493; Boulenger, Proc. Zool. Soc. London, 1887, p. 149.

Platurus laurenti: Rafinesque, Amer. Month. Mag., vol. 1, 1817, p. 432 (not of Daudin) a substitute name.

Coluber platycaudatus: Oken, Allgem. Naturg. vol. 8, 1836, p. 566.

Platurus fischeri: Jan, Rev. Mag. Zool., 1859, p. 149; Jan and Sordelli, Inconographie générale des Ophidiens, 1872, pt. 40, pl. 1, fig. 2, type (type-locality, "Océan des Grandes Indes"); Günther, The reptiles of British India, 1864, p. 356 (M. Smith believes the record incorrect); Anderson, Proc. Zool. Soc. London, 1871, p. 189; Fayrer, Thanatophidia of India, 1874, p. 24. Col. plate 18.

Platurus n. sp. F. Müller, Verh. Nat. Ges. Basel, vol. 10, 1892, p. 207.

?Platurus muelleri Boulenger Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 309 (type-locality, South Pacific; this is based on the preceding reference).

Diagnosis: A large species characterized by a light ground color with bands of gray, bluish gray, or ultramarine which tend to surround body. Head black with a curved yellow mark; no azygous prefrontal scale; upper lip dark brown.

The presence of this snake in Thai waters is problematical. It is known from the Bay of Bengal whose waters bound the western side of peninsular Thailand, and in waters south of Japan. This snake usually finds habitat in the neighborhood of small islands and utilizes them for breeding grounds or for the rearing of young. One island may have thousands and many other neighboring islands may have none. Careful exploration of small islands west of peninsular Thailand will probably disclose the presence of such colonies there. Günther reports it from the Gulf of Siam.

The extensive synonymy shows that the species has certain geographical variations that may warrant subspecific consideration (not impossibly specific).

Description of species (largely after Malcolm Smith [1926]): Body subcylindrical of nearly uniform diameter throughout. Rostral

higher than wide; no azygous shield between internasals and prefrontals; frontal longer than its distance from end of snout, as long as parietals; one pre- and two postoculars; seven supralabials, third and fourth bordering orbit; temporals, 1 + 2; seven infralabials concealed largely by supralabials, four or five of which border first chinshields; two pairs of chinshields in contact, anterior pair the smaller; mental very small; often some tiny scales outside infralabials along oral border.

Scalerows: 19, 19, 17, scales smooth without pits; ventrals, 225-243, about four times as broad as long; anal, divided, subcaudals, 38-47 pairs in males, 30 to 35 in females. A median ventral keel sometimes present on posterior part of body.

Color: Bluish gray to ultramarine above, yellowish below with black bands of more or less uniform width throughout, some or all of which may be complete below. Head black with a curved yellow mark above, color often extending forwards to cover whole of snout and downwards behind eyes to reach lip. A median elongated patch of yellow on underside of jaw variable in width, usually connecting with first yellow ring on neck.

Measurements in mm.: Male, total length, 910; tail, 110. Female, 1070; tail, 110.

Variation: The number of black bands is variable in various populations. In the Japanese area the number of such bands is 39 to 55; in Java as few as 20; in the Sulu sea, as many as 66.

Distribution: Widely distributed from the Riu Kius, Philippines to Australia, west through the Indo-Australian Archipelago to Java and Sumatra and the coast of Bengal.

Günther under the name of *Platurus fischeri* reports a specimen from the Gulf of Siam near Chartaboum (Chanthaburi). While Malcolm Smith states that this record "is probably incorrect," there is no specific reason for thinking so.

Aipysurus Lacépède

Aipysurus Lacépède, Ann. Mus. Paris, vol. 4, 1804, p. 197 (type of genus, *A. laevis*).

Aepyurus Agassiz, Nomenclator zoologi index, univ. 1846, p. Berg. Comm. Mus. Nac. Buenos Aires, vol. 1, (8) 1901, p. 289 (emendation or correction).

Maxillary bone extending forward beyond the palatine; poison-fangs followed after a diastema by from five to eleven teeth; head-shields complete or divided; nasals in contact, nostrils dorsal; scales

imbricate, in 17 to 25 rows; ventrals widened, one-third to one-half times width of body. Body subcylindrical of nearly equal diameter throughout.

Seven or eight species are known, distributed from the southeastern Asiatic coasts to Australia and Oceania. One only has been taken in the Gulf of Siam.

Aipysurus eydouxii (Gray)

(Fig. 99)

Tomogaster eydouxii Gray, Catalogue of the snakes in the British Museum, 1849, p. 59 (type-locality, Indian Ocean).

Aipysurus eydouxii: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 304; A vertebrate fauna of the Malay Peninsula, . . . Reptilia and Batrachia, 1912, pp. 195-196; Wall, Mem. Asiat. Soc. Bengal, vol. 2 (8), 1909, p. 189; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 219, fig. 84; Malcolm Smith, Journ. Federated Malay States Mus., vol. 10, 1920, p. 34; Taylor, Snakes of the Philippine Islands, 1922, pp. 226-227; Bourret, Serpents marins Indochine Française, 1935, p. 20; Les serpents de l'Indochine, 1936, p. 343, fig.; M. Smith, Monograph on the sea-snakes (Hydrophiidae), 1926, pp. 14-16, fig. and Bull. Raffles Mus., no. 3, 1930, p. 71.

Aepyurus eydouxi: M. Smith, The fauna of British India, Ceylon and Burma, . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 445-446; Tweedie, The snakes of Malaya, 1954, pp. 103-104.

Thalassophis anguillaeformis Schmidt, Abh. Naturw. Ver. Hamburg. vol. 2, 1852, p. 76, Colored plate 1 (type-locality, Java).

Aipysurus anguillaeformis: Günther, Reptiles of British India, 1864, p. 357.

Thalassophis muraenaeformis Schmidt, Abh. Naturw. Ver. Hamburg, vol. 2, 1852, pp. 76-77, pl. 1; Boettger, Zool. Anz., 1892, p. 420.

Aipysurus margaritophorus Bleeker, Nat. Tydschr. Ned. Ind., vol. 16, 1858, p. 49 (type-locality, Java).

Aipysurus laevis: Guichenot, Voyage Pole Sud. Zool. vol. 3, 1853; Rept. p. 21, pl. 6; Duméril and Bibron and Duméril, Erpétologie Générale . . . vol. 7, 1854, p. 1326, Atlas. pl. 77 bis; Fischer, Abh. Naturw. Ver. Hamburg, vol. 3, 1856, p. 32; Jan and Sordelli, Icongraphie générale des ophidiens, 1872, pt. 40, pl. 2, Sauvage, Bull. Soc. Philom, 1877, p. 112.

Diagnosis: A sea-snake, usually little more than half a meter in length; poison-fangs followed by 10 to 13 small maxillary teeth; two, sometimes four, prefrontals; two anterior temporals; second supralabial not touching prefrontal; scales in 17 rows, smooth imbricate. Low ventral count, 129-144, each with a median keel; and each one third to one half of the width of the body.

Description of species (from C.U. No. 2684): Body compressed the diameter at widest point more than double the diameter of head; ten to eleven small maxillary teeth follow behind poison-fangs; diameter of eye greater than its distance from mouth; frontal large, longer than its distance from end of snout; two prefrontals; one

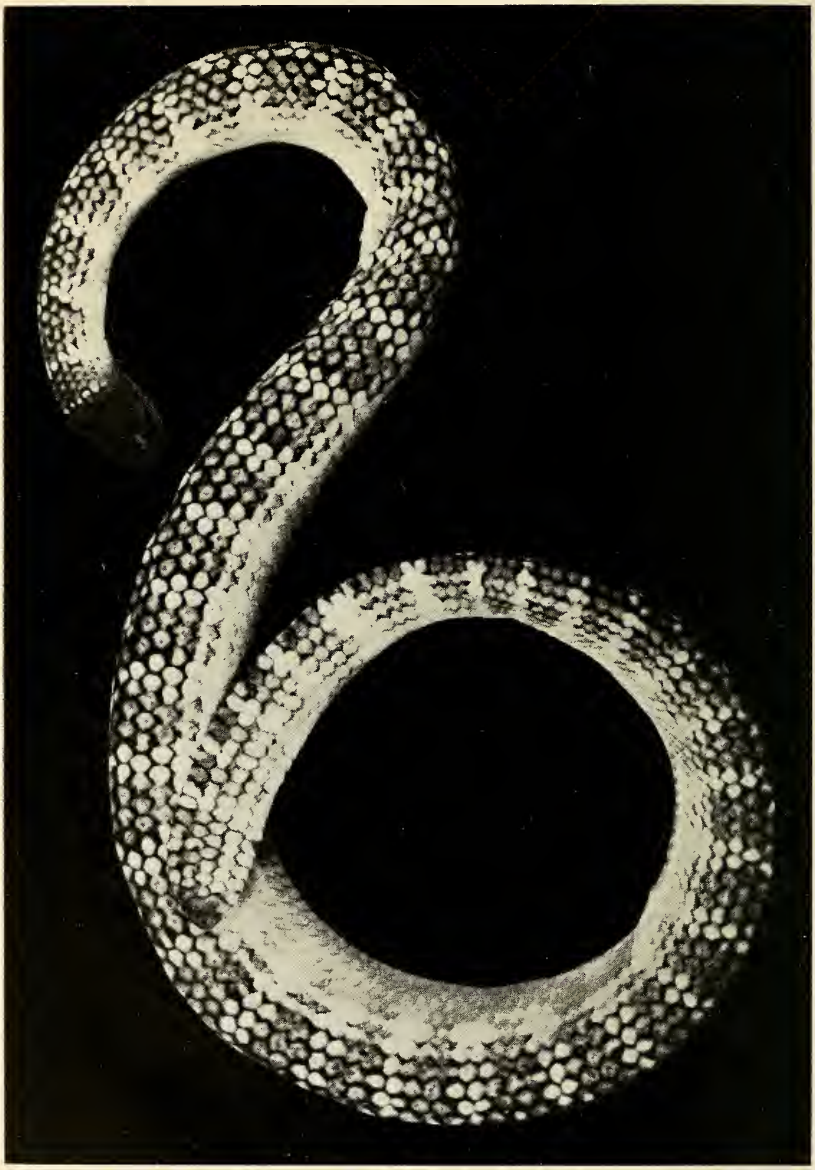

FIG. 99. *Aipysurus eydouxi* (Gray). C.U. No. 2684, Gulf of Siam. Actual total length, 660 mm.; tail, 100 mm.

large preocular, two large postoculars; two anterior temporals; supralabials, six, second slightly in contact with prefrontal, fourth borders orbit, sixth longest; infralabials six, first four in contact with chinshields, first pair very large, in contact with one another behind mental, as large as first chinshields; latter slightly shorter than second pair which is separated by small scales.

Scalerows: 17 on neck and body, 15 before vent, all imbricate and entirely smooth; ventrals, 144 each with a distinct tubercle, the last one divided; anal, divided; subcaudals, 32, single, last subcaudal a vertically compressed plate.

Color: Brownish or olive above with 39 cross-bands of yellow black-edged scales, often broken up on vertebral line, and occasionally alternating on the two sides; these bands widen towards venter, which is yellow. Head in adults, dark olive, blackish in young, the black extending on neck. On occiput a row of seven ocellated spots.

Measurements in mm.: Total length, 660; tail length, 100 (specimen from Hua Hin, Chon Buri).

Variation: The squamation of the head is usually very constant except the above mentioned division of the prefrontals, while the keeling on ventral scales may be poorly or strongly developed, or anteriorly the keels may termiate in a strong spine. Rarely the bands are continued across the venter. A specimen from the Gulf of Siam had a rich slate-blue iridescence in life. The largest known specimen measured 910 mm. Ventrals vary between 129 and 144, the subcaudals from 23-32. The number of bands varies from 44 to 55, on body and tail.

Distribution: The species is known from the northern part of the Gulf of Siam (Bight of Bangkok). Intensive collecting at Songkhla yielded no specimens.

This species one of the most widely distributed serpents, is known along the coasts of Cochin China and Viet Nam, and through the Indo-Australian Archipelago to the Philippines and to Queensland in Australia.

Subfamily HYDROPHIINAE Boulenger

Hydrophiinae Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 393.

This subfamily comprises all but two of the genera of the sea-snakes the exceptions being (*Laticauda* and *Aipysurus*). All of these are marine species with the exception of *Hydrophis semperi* (Lake Taal, Philippines) and perhaps one *Hydrophis* in the Sea of Singgora in Nakhon Si Thammarat, a body of water that in its

northern end is practically fresh, while in the southern part the water is almost typically marine.

While the members of the genus *Laticauda* spend considerable time out of the water on land, none of the Hydrophiinae can survive more than a few days at most, and snakes tossed high on shore or left by a receding tide are likely to die before the return of the tide, if exposed to sun-heat. Ordinarily they cannot crawl the few meters necessary for a return to the water; however aimless flopping about could accidentally accomplish the return.

All the Hydrophiinae are ovoviviparous, the young being born in the water. There are reports that certain of the Laticaudinae are oviparous.

KEY TO THAI GENERA OF THE HYDROPHIINAE

1. Not more than 23 scalerows around middle of body; ventrals distinct, undivided. Head shields regular; no distinct diastema follows poison-fangs; body of nearly equal diameter throughout; snout somewhat pointed ..... *Kerilia*
   More than 25 scalerows around body at thickest part 2
2. Scalerows about thickest part of body, 75 to 93, small irregular; ventrals, 320 to 368; a pair of internasals ..... *Kolpophis*
   Fewer than 70, but more than 23 scalerows about thickest part of body ... 3
3. Head-shields normally regular and entire 4
   Head-shields especially frontals and parietals breaking up into small scales 6
4. Ventrals relatively broad anteriorly on body, narrowed posteriorly; mental shield normal; five maxillary teeth behind fangs ..... *Praescutata*
   Ventrals present (rarely absent), small, uniform throughout 5
5. Three to five maxillary teeth behind fangs; mental slender, elongate, at least partly concealed in mental groove ..... *Enhydrina*
   One to eighteen maxillary teeth behind fangs; mental normal, not concealed. Head large or small ..... *Hydrophis*
6. A pair of internasals present, separating nasals 7
   No internasals separating nasals 8
7. Five to seven maxillary teeth behind fangs; scales subimbricate; ocular scales and nasal with somewhat spinous edges ..... *Acalyptophis*
   Five maxillary teeth follow poison-fangs; no spinous elevations on edges of ocular or other head scales ..... *Thalassophis*
8. Head very small, anterior third of body very slender; ventrals divided by a fissure; scales juxtaposed; five or six maxillary teeth follow fangs, *Microcephalophis*
   Head not small; anterior part of body not proportionally slender 9
9. Eight to ten maxillary teeth behind poison-fangs; body greatly compressed; ventrals with a median groove. Scales subquadrangular, juxtaposed ..... *Pelamis*
   Fewer than eight maxillary teeth behind poison-fangs; body not greatly compressed 10
10. Large snakes of large girth; scales on dorsum somewhat pointed behind, strongly imbricate; ventrals with a median groove; six or seven maxillary teeth behind poison-fangs ..... *Astrotia*
    Smaller snakes (less than one meter), the scales on dorsum subquadrangular, juxtaposed; three to six maxillary teeth behind poison-fangs, *Lapemis*

Genus KERILIA Gray

Kerilia Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 57 (type of genus, *jerdoni*); M. Smith, Monograph of the sea-snakes (Hydrophiidae) 27, Nov. 1926, p. 31; The Fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 446.

Hydrophis Günther, Reptiles of British India, 1864, p. 360 (*part.*).

Distira Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 285 (*part.*).

Diagnosis: Maxillary bone longer than ectopterygoid, extending forwards beyond palatine; poison-fangs moderate, followed practically without a diastema, by from seven to nine smaller teeth; snout narrowed anteriorly and sloping downwards; nasals in contact, nostrils dorsal; scales relatively large, imbricate, in regular rows, strongly keeled; ventrals about as wide as adjoining scales, usually with two keels; head-scutes complete, not fragmented; usually a preocular; one postocular.

Only a single species is recognized, with two subspecies, one of which is known in Thailand, and the other may very probably occur.

Kerilia jerdonii Gray

Kerilia jerdonii Gray, Catalogue of the snakes in the collections of the British Museum, 1849, p. 57 (type-locality Madras, India); Wall, Ophidia Taprobanica, or the snakes of Ceylon, 1921, pp. 386-390, fig. 73; Smith, Bull. Raffles Mus., no. 3, 1930, pp. 71-72; Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 31-32, fig. 15; The Fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes 1943, pp. 446-447, fig. 143.

Hydrophis jerdonii: Günther, Reptiles of British India, 1864, p. 362, pl. 25, fig. B; Anderson, Proc. Zool. Soc. London, 1871, p. 190; Fayrer, Thanatophidia of India, 1874, pl. 20; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia; 1912, p. 186; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 232; Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 28-29.

Distira jerdonii: Boulenger, Fauna of British India, Ceylon and Burma, Reptilia and Batrachia; 1890, p. 408; Boettger, Mitth. Geogr. Ges. Nat. Mus. Bremen., ser. 2, vol. 5, 1893 (not seen); Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 299; Sclater, List of the snakes in the Indian Museum, 1891, p. 65; Wall, Mem. Asiat. Soc. Bengal, 1906, p. 293, vol. 2, (8), 1909, p. 241, fig.

Hydrus nigrocinctus: Cantor, Cat. Mal. Rept., 1847, p. 129, pl. 40, fig. 8.

Hydrus cantori Jerdon, Journ. Asiat. Soc. Bengal, vol. 22, 1854, p. 526.

KEY TO SUBSPECIES OF KERILIA JERDONI GRAY

19-21 scalerows around middle of body; 30 to 38 black dorsal bars; three infralabials touch first chinshields . . . . . *jerdonii jerdonii*

21-23 scalerows around middle of body; 38 to 61 black bars on body; three (rarely four) infralabials touch first chinshields; first temporal and sixth supralabial frequently joined (approximately 50%), *jerdonii siamensis*

It is possible that *K. jerdonii jerdonii* will be found on the west coast of peninsular Thailand since it has been reported at Penang. The other subspecies, *K. jerdonii siamensis* is one of the more common sea-snakes in the lower part of the gulf of Siam.

Kerilia jerdonii siamensis M. Smith

(Fig. 100)

Kerilia jerdonii Gray, Catalogue of the snakes in the British Museum, 1849, p. 57 (type-locality, Madras, India).

Distira jerdonii: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., 1896, vol. 3, p. 299 (*part.*).

Kerilia jerdoni siamensis M. Smith, Monograph on the sea-snakes (Hydrophiidae), 1926, p. 32 (type-locality, Pattani Bay, Thailand).

Hydrophis jerdoni: de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 232; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 28-29, 57.

Diagnosis: Characters of the genus: this differs from the Indian form occurring in the Bay of Bengal in having more dorsal bars (34 to 50) on body (mean, 46).

Description of subspecies (from No. 693, Songkhla, at mouth of Singgora Sea): Head scarcely distinct from neck; rostral as wide as high, largely visible above, pointed behind; nasals a little longer than wide, broadly in contact; nostril dorsal, in outer posterior part of nasal scale; prefrontals about half area of nasals; frontal longer than wide, shorter than its distance from end of snout, shorter than parietals, wider than supraoculars; parietals about twice as long as wide; a small preocular; one postocular; one anterior temporal fused with sixth labial; supralabials, 6-6, third and fourth broadly bordering orbit, first smallest; seven infralabials, first three only border first pair of chinshields, which are equal or somewhat larger than second pair; eye small, its greatest diameter less than its distance from mouth, equal to its distance from nostril; scales in regular rows, strongly keeled except on neck.

Scale-formula: 17, 21, 21, the scales broader than long, imbricating; ventrals, 240; anals, 4; subcaudals, 34; ventrals usually wider than adjoining scales, frequently smaller or divided; when keels are present on ventrals there are usually two.

Color in life: Blue-gray to ultramarine on eight or ten dorsal scalerows; laterally and ventrally yellowish; a series of 39 black bands on body, 4 + on tail; bands widened dorsally, narrowing on sides, not crossing venter (occasionally vaguely indicated on venter). Top of head clouded with bluish gray; chin-scales dirty brownish-white.

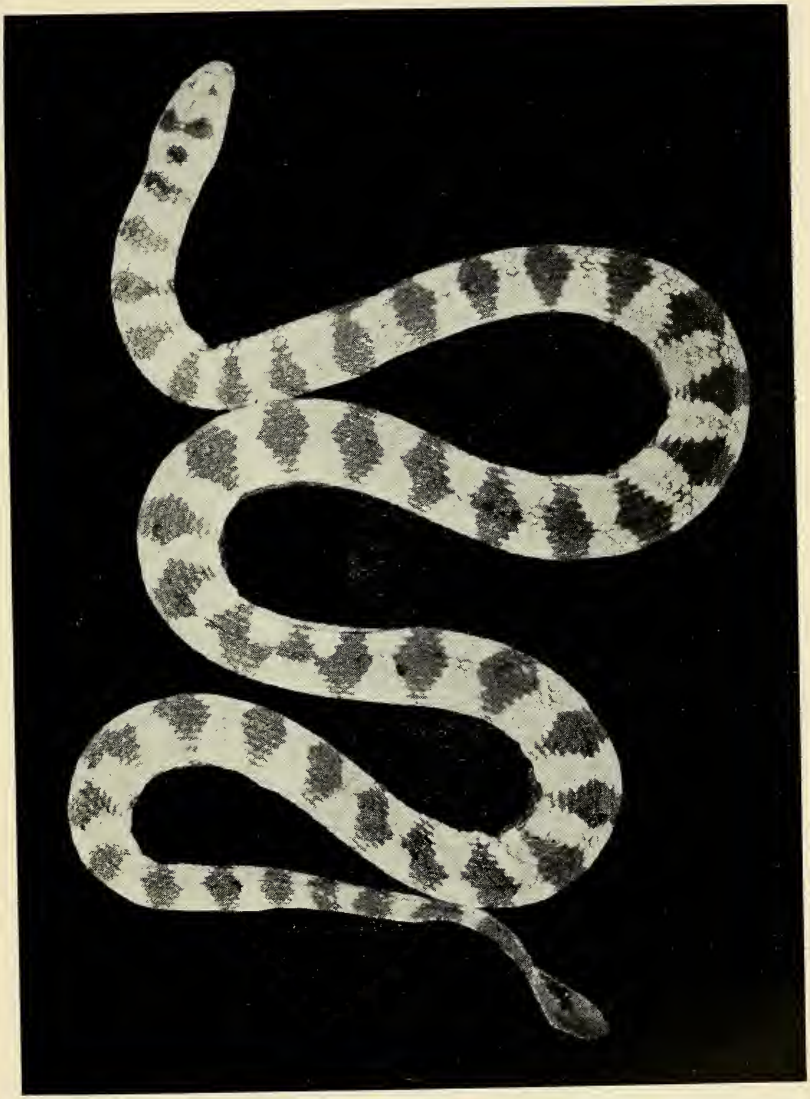

FIG. 100. *Kerilia jerdonii, siamensis* M. Smith. No. 34610, Songkhla, Songkhla province, southern Thailand. Actual total length, 455 mm.

Measurements in mm.: Total length, 938; tail, 87; head-width, 18.2; head-length, 25.

Variation: Dr. Malcolm Smith has designated the form of *Kerilia* found in the Gulf of Siam as, *Kerilia jerdonii siamensis* on the basis of a series of specimens taken at Songkhla and Pattani.

My series of specimens from Songkhla was able to confirm his findings as regards the increased number of bands about body and tail. The number of the infralabials touching the first chinshields was three in 39 cases (considering the two sides); four cases where there were only two, and only a single case where four were in contact. Only a single specimen was found with 23 scales about the body; all the others had the formula 17 (18), 21 (20), 21.

There was one character that appeared frequently in the series. Considering again the 22 specimens (44 cases), the first temporal was fused with the sixth labial in 24 cases, separate in 20. There was a tendency for the preocular to fuse with the prefrontal; in four specimens it was fused on both sides, in three others on one side only, while it was separated in the remainder.

The counts of the number of bands on body and tail resulted in a spread from 38 to 61 (mean, 46). The specimen having 38 bands was otherwise seemingly within the variable limits for other characters of the species; that with 61 bands also had a larger number of ventral and subcaudals than the average (284). Only one higher count was found, (293) with 45 bands. Ventral counts in the Songkhla series was from 224 to 254 (the mean, 235), the subcaudal count from 30-43. In one specimen the bars are joined together on the back, while in another they form a zig-zag line.

Remarks: The food, at least in the younger specimens, consists chiefly of slender eels.

Distribution: Gulf of Siam. As yet known there only at Pattani and Songkhla.

Genus *Astrotia* Fischer

Astrotia Fischer, Abh. Naturw. Ver. Hamburg, vol. 3, 1856, p. 38 (type of genus, *schizopholis*).

Diagnosis: Large snakes. Maxillary bone longer than lower aspect of ectopterygoid, not reaching forward as far as palatine which is curved outwards. Poison-fangs followed by a diastema and then six or seven smaller teeth. Shields on head large, usually regular; nostrals directed upwards; nasals in contact; scalerows 47-59 on body; most ventrals divided into two parts. Body scales strongly imbricate.

Only a single species is recognized. It was described twice in 1846, by Gray as *Hydrus stokesii* from the Australian Seas, and by Schmidt (1846), as *Hydrophis schizopholis* from the China Sea. Two other forms described have been placed in synonomy by

Data on *Kerilia jerdonii siamensis*

NUMBER	478	193	476	325	34601	337	672	552	571	336	282	477	555
Total length	960	938	850	411	446	490	524	433	433	418	419	405	390
Tail	106	87	93	49	49	47.6	60.5	48	42	48	41	39	39
Head-width	20	18.2	15	9	9	10	.....	9.6	9	9.2	9.2	9.5	9.2
Head-length	29.5	25	21.5	13.2	13	15.7	17	15	14.4	14.6	15	16	14.6
Ventrals	231	229	232	224	238	225	234	242	256	241	225	235	245
Subcaudals	38	34	39	40	38	33	32	42	39	43	30	33	36
Scalerows, neck	17	17	17	17	17	17	18	17	17	19	17	17	18
Scalerows, middle	21	21	21	21	21	21	21	21	21	23	21	21	21
Scalerows at vent	21	20	21	21	21	21	21	21	21	23	20	21	21
Preoculars	1	1	1	1	1	1–0	0–0	1–1	1–1	1–1	0–0	1–1	1–1
Postoculars	1	1	1	1	1	1–1	1–1	1–1	1–1	1–1	1–1	1–1	1–1
Supralabials	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6	6–6
Labials enter orbit	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2
Infralabials	6–6	6–6	7–7	7–7	7–7	7–7	7–7	7–7	7–7	7–8	6–6	7–7	7–7
Labials border chinshields	3	3	3	3	3	3–3	3	3	3	3	2–2	3–3	3–3
Body bands	41	41	42	39	39	43	39	55	41	38	43	42	48
Tail bands	5	3+	4	4+	5+	4+	5+	6+	4+	5+	4+	4+	5+

Malcolm Smith, the types of both having been lost. I am not certain that Gray's name actually antedates that of Schmidt. M. Smith the most important reviser of the group has chosen the name proposed by Gray.

A remarkable report on the breeding of this species is quoted by M. Smith, (*loc. cit.*, 1943, p. 440).

Astrotia stokesii (Gray)

(Fig. 101)

Hydrus major (*part.*) Shaw, General zoology, vol. 3, 1802, p. 558.

Hydrus stokesii Gray, in Stokes, Discovery of Australia, vol. 1, 1846, p. 502, pl. 3 (type-locality, "Australian Seas").

Hydrophis stokesii: Günther, Reptiles of British India, 1864, p. 363; Peters and Doria, Ann. Mus. Civ. Genova, vol. 13, 1878, p. 415; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 183-184.

Distira stokesii: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 408; Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, pp. 288-289.

Astrotia stokesii: Wall, Mem. Asiat. Soc. Bengal, vol. 2, 1909, p. 250; Ophidia Taprobanica or the snakes of Ceylon, 1921, pp. 396-400, fig. 75; M. Smith, Monograph of the sea-snakes (Hydrophiidae), Nov. 27, 1926, pp. 113-115; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec., 1943, pp. 440, 471-472 ("Mekran coast, Colombo, Ceylon; Bay of Patani on the east coast of the Malay Peninsula; Singapore; and the north coast of Australia").

Hydrus annulatus Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 59 (type-locality, Singapore).

Hydrophis schizopholis Schmidt, Abh. Naturw. Ver. Hamburg, vol. 3, 1846, pp. 166, col. pl. 15 (type-locality, "China Sea").

Astrotia schizopholis: Fisher, Abh. Naturw. Ver. Hamburg, vol. 3, 1856, p. 38; Jan and Sordelli, Iconographie générale des Ophidiens, pt. 39, 1872, pl. 3.

? *Hydrophis granosa* Anderson, Proc. Zool. Soc. London, 1871, p. 100 (type-locality, Indian coast).

Hydrophis guttata Murray, Journ. Bombay Nat. Hist. Soc., vol. 2, 1887, p. 34 (type-locality, Mekran coast).

Diagnosis: Head scales large, regular; body proportionally very stout; 37-47 scalerows on neck; 47-59 scalerows on body; scales imbricate, pointed, keeled, or tuberculate; ventrals, 226-286, a few anterior ones entire, others divided; preanals strongly enlarged. Body with bands and ventral spots.

Description of species (from No. 34335 ♂, Ang Hin, Chon Buri): Rostral small, a little broader than high, well visible above; nasals broadly in contact on median line, scales partly divided by sutures from nostril to second labial (on right side completely severed); prefrontals small, a little wider than long, their common suture considerably less than their length; frontal relatively small, longer than wide, much shorter than its distance from tip of snout, much shorter than parietals; latter tending to break up into smaller scales

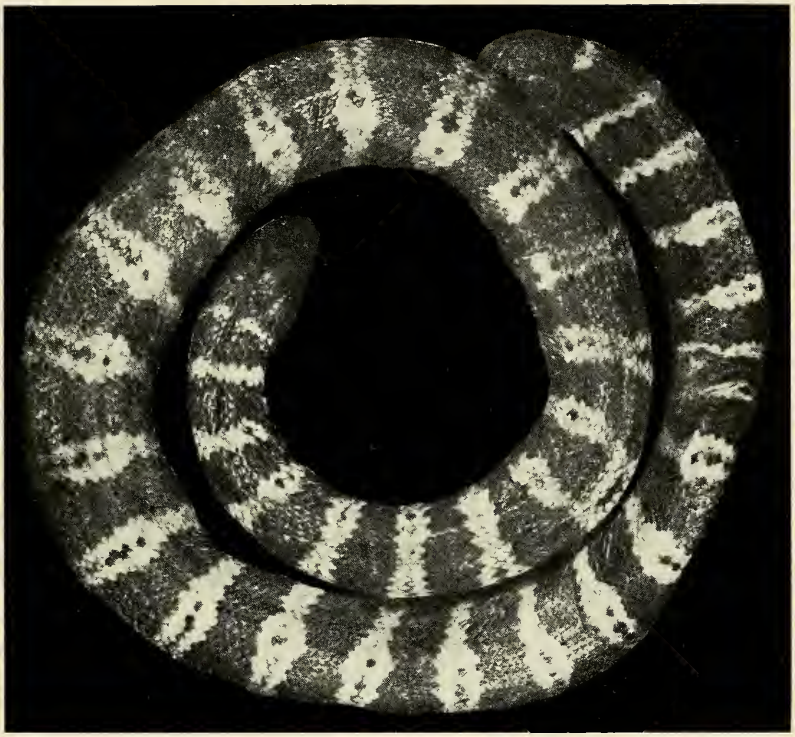

FIG. 101. *Astrotia stokesii* (Gray). No. 34335, Ang Hin, Chon Buri, southeastern Thailand. Actual total length, 1215 mm.; tail 175 mm.

posteriorly; a preocular; two postoculars; supraoculars narrower than frontal; a large upper anterior temporal and a smaller lower one, both touching postoculars; lower scale followed by two other temporals, the arrangement being, $\frac{1}{3}$; eight supralabials, second largest, third, fourth, and fifth bordering orbit; last three small (suggesting that last three labials had been divided and upper parts were now temporals); infralabials eleven; chinshields small, scarcely differentiated; first infralabials elongate, broadly in contact behind small anteriorly emarginate mental; two or three enlarged scales bordering posterior infralabials.

Scalerows: 36 on occiput; 32 on neck, 44 at middle of body; 36 before vent; 24 at broadest part of tail; the scales all strongly imbricate. Anterior ventrals enlarged somewhat; about 12 scales between mental and first ventral; first 16 ventrals single, other 217

divided (total count 233); about 43 subcaudals; a pair of enlarged anals; other anal scales only slightly enlarged. All scales keeled, the keels shorter on venter than on dorsum.

Color: Head brownish black, nearly uniform, the color extending four or five scalerows behind parietals. Body gray-black with a series of 29 cream bands, each varying from two to six scales in width, all except first passing entirely around body; cream bands with a few more or less scattered black scales; five complete narrower cream bands on tail, one incomplete. Anal scales whitish.

Measurements in mm.: Total length, 1215; tail, 175; width of head, 36; length of head, 50; depth of body, 62.

Variation: Many of the scales have the keel divided into two or three tubercular elevations; scales on occiput and anterior part of neck smooth; two or three anterior temporals; eight to ten supralabials; ten to twelve infralabials.

Scalerows on the neck vary between 37 and 47; on body, between 47 and 59. Ventrals vary between 226 and 286, the divided ventrals with bifid or bidentate tips. The head may be dark olivaceous or somewhat yellowish.

The number of bands varies from 32 to 36 and these are usually retained throughout life. The largest specimen reported, a female, reaches a length of 1600 mm.; the tail, 190 mm.

Distribution: In Thailand the species has been taken near Ang Hin, Chonburi, and the Bay of Pattani, Gulf of Siam. It is known from Singapore, Ceylon, Malaya and the northern coast of Australia.

Remarks: This is the largest sea serpent in girth and perhaps in weight. The type measures 260 mm. about middle of body. The specimen described is from a fish trap near Ang Hin, Chon Buri Thailand.

Genus *Kolpophis* Smith

Kolpophis Smith, Monograph of the sea-snakes (Hydrophiidae), Nov. 27, 1926, p. 106 (type of genus, *annandalei*).

"Maxillary bone longer than the lower aspect of the ectopterygoid, not extending forwards as far as the palatine; poison-fangs followed after an interval by six or seven teeth; nostrils superior; head-shields irregularly divided. Head large, body stout, covered with small, irregular, juxtaposed scales; ventrals small but distinct throughout."

Only a single species is recognized, *Kolpophis annandalei* (Laidlaw).

Kolpophis annandalei (Laidlaw)

(Fig. 102)

Disteira annandalei Laidlaw, Proc. Zool. Soc. London, 1901, p. 579, pl. 35 (type-locality, Pattani Bay).

Thalassophis annandalei: Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 16; Wall, Mem. Asiat. Soc. Bengal, vol. 2, 1909, p. 245; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 195; Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, 1915, p. 214; de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 223-224, fig. 87 (head scales); Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 29-30, 59.

Kolpophis annandalei: Smith, Monograph of the Sea Snakes, 1926, pp. 106-107, fig. 3; Smith, Bull. Raffles Mus., no. 3, 1930, pp. 83-84; Bourret, Serpents Marins Indochine Franç., 1935, p. 55; M. Smith, The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, vol. 3, Serpentes, Dec. 1943, pp. 467-468; Tweedie, the snakes of Malaya, 1954, p. 111.

Diagnosis: A sea snake, with head rather large; body short and stout, the greatest diameter of body usually less than twice diameter of neck. Scales very small, non-imbricating, 74-93 around widest part of body; ventrals small distinct. Head scales tend to break into smaller scales; parietals separated by small scales; 35-45 gray dorsal rhombs or bars, much broader than the interspaces between them.

Description of species (from No. 34633, Songkhla): Rostral somewhat quadrangular, not fragmented, visible above as a transverse line; this bordered behind by a pair of large anterior nasals extending posteriorly between much smaller posterior nasals, in which nostril is pierced; two internasals, left one fused to anterior nasal; prefrontals touching posterior nasal, preocular, and one loreal; frontal partly broken into small scales; small scales separate parietals, which are likewise partly fragmented; supraoculars large, nearly as wide as frontal; on right side four large anterior labials, fourth entering eye; remainder of labials fragmented leaving a row of six small scales along lip; three suboculars entering orbit; temporals $3 + 5 + 5$; one preocular and two postoculars; on left side only first and third supralabials unfragmented, with a total of eleven scales bordering lip; three or four loreals, three suboculars, one preocular, and two postoculars; diameter of eye equal or slightly less than its distance from mouth. Mental small with a pair of small latero-anterior horns; first pair of chinshields scarcely differentiated; second not differentiated; infralabials fragmented except first three pairs; 15-17 scales border lower lip; diameter of eye greater than its distance from mouth.

Scales small, juxtaposed, not or slightly tuberculate; body compressed, especially so posteriorly. Scales in 63 rows about occiput, 76 on neck, 96 at widest part of body, 48 in front of vent; 15 scales

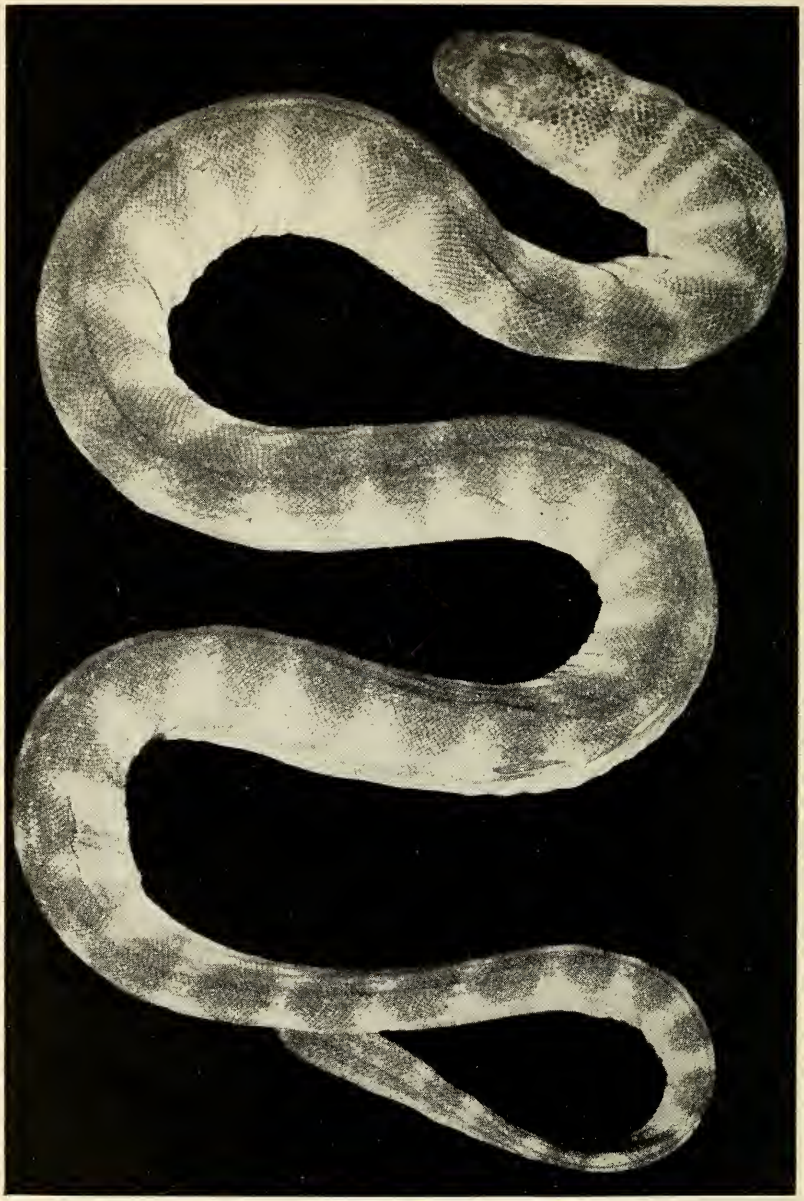

FIG. 102. *Kolpophis annandalei* (Laidlaw). No. 34633, Songkhla, Songkhla province, Thailand. Actual total length, 480 mm.; tail, 54 mm.

between chinshields and first ventral; ventrals 286; subcaudals, 76; a pair of enlarged lateral anal scales; between these and last complete ventral, several pairs of widened ventrals, terminal one widest and bordered by one or two small lateral scales; ventrals usually enlarged throughout but occasionally a few of these scales divided. Maxillary with two enlarged grooved fangs, followed after a long diastema by five subequal teeth.

Color in life: Above yellowish olive with a series of gray-olive rhombs, bands, or saddles, incomplete below, much wider than interspaces, and narrowing laterally, 40 on body, six on tail; tip of tail blackish-olive; venter whitish or cream; head variegated dark gray or dark olive with lighter clouded areas behind eyes.

Table of measurements and data on *Kolpophis annandalei*

NUMBER	34632	34633	34631	34634
Sex	♂	♂	♂	♀
Total length	454	480	534	643
Tail	59	54	65	80
Head-width	14.5	14.2	16	16.5
Head-length	27	26	28	31
Scalerows, neck	76	65	73	75
Scalerows, widest part	96	79	86	85
Scalerows before vent	48	58	58	56
Dorsal rhombs	40	47	45	45
Tail rhombs	6	7	7	7
Ventrals	386	346	394	380
Subcaudals	76	65	81	76

* Nos. 34631-34634, Songkhla.

Variation: The species reaches a known length of 910 mm ♂. The number of dark rhombs on body varies between 35 and 47 in number; the ventrals vary between 320 and 403. Scalerows on the neck vary between 62 and 68, and those around the body between 74 and 96. There are 15 to 20 scales between the first chinshields and the first widened ventral.

Three of my specimens have the very small posterior nasal scale completely separated from the anterior by a separate pair of internasals situated behind the elongated anterior nasals. Most of the labials are fragmented, leaving one or more "suboculars" and from one to four "loreal" scales.

The number of "supralabials" (scales bordering the upper lip) varies from 9 to 13, the infralabials, 9 to 14. In all four specimens listed, one to four of the labials may remain unbroken. One

specimen has the nostril opening between the two nasals that are partially fused together. The individual scales may be smooth or they may have a short keel or tubercle.

A series of specimens from Pattani Bay differs somewhat in the number of scalerows and ventrals from a series from the Singgora Sea at Songkhla. The counts are as follows: (Songkhla) Females: scales about neck, 65; scales about widest part of body, 79; ventrals, 346; six males: scales, 75 to 87, ventrals average 380; (Pattani), females: scales, 76 to 90, ventrals, 346 average; males, 70 to 84, 355 average. The samples, however, are too small for the differences to be signifiicant.

The rhombs on the back tend to become less distinct with age, and the back may be uniform gray.

Distribution: In Thailand specimens have been taken in the Gulf of Siam, chiefly along the coasts of Pattani, and Songkhla and in the Singgora Sea. Elsewhere it occurs along the coasts of Cambodia and Viet Nam.

Genus *Praescutata* Wall

Praescutata Wall, The snakes of Ceylon, 1921, p. 390 (type of genus, *viperina*).
Thalassophina M. Smith, Monograph of the sea-snakes (Hydrophiidae), Nov. 27, 1926, p. 33 (type, *viperina*).

Diagnosis: Nostrils on dorsal surface of snout; nasal scutes in broad contact with each other; head-scutes complete, large, regular; body moderately elongate; ventrals widened on anterior part of body, much narrowed on posterior part of body; dorsal scales about body 37-50 very slightly imbricating anteriorly, farther back, juxtaposed; on upper part of tail, scales imbricating, all keeled or tuberculate, and usually hexagonal in shape. Maxillary bone not reaching as far forward as the palatine; latter curves outward; poison-fangs followed, after a diastema, by five maxillary teeth; parietals broad, with a pair of pointed lateral prongs.

Praescutata viperina (Schmidt)

(Fig. 103)

Thalassophis viperina Schmidt, Abh. Naturw. Ver Hamburg, vol. 2, 1852, pt. 2, p. 79, pl. 3 (type-locality, Java); M. Smith, Monograph of the sea-snakes (Hydrophiidae), Nov. 27, 1926, pp. 33-34, fig.; Pope, The reptiles of China, 1935, p. 356; Bourret, Serpents marins Indochine Française, vol. 1, 1935, p. 28; Les serpents de l'Indochine, 1936, p. 349.

Hydrophis viperina: Günther, Reptiles of British India, 1864, p. 378; Boulenger, Ann. Mag. Nat. Hist., ser. 6, vol. 2, 1888, p. 44; Anderson, Proc. Zool. Soc. London, 1872, p. 40.

Hydrophis viperinus: de Rooij, Snakes of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 231-232; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 27-28, 56.

Praescutata viperina: Wall, The snakes of Ceylon, 1921, p. 391-396.
Hydrophis plumbea Murray, Journ. Bombay Nat. Hist. Soc., vol. 2, 1887, p. 34.
Hydrophis nigra Anderson, Proc. Zool. Soc. London, 1872, p. 399 (type-locality, Puri, Orissa); Fayrer, Thanatophidia of India, 1874, p. 28, pl. 25 (figure of the type); Wall, Mem. Asiat. Soc. Bengal, vol. 2, no. 8, 1909, p. 240, fig.
Hydrophis schistosus: Boulenger, Catalogue of the snakes in the British Mus., vol. 3, 1896, p. 274 (*non* Daudin).

Diagnosis: Characters of the genus. Blue-gray above, with a series of dark rhomboidal spots, 25 to 35 in number, which may anastomose on dorsum, or in older examples, disappear. Ventrals (in Thai specimens), ♂ 247, ♀ 2 + 2; head short somewhat flattened, distinct from neck, the snout broadly rounded; eye rather golden with a dark pupil.

Description of species (from No. 501, Songkhla): Rostral slightly wider than high, well visible above; nasals large, broadly in contact; nostrils dorsal, with sutures running from nostrils to first labials (very near to suture between first and second labials); prefrontals small, their common suture about one third that between nasals, separated from labials; frontal as broad as long, pointed posteriorly, more than double width of supraoculars, not as long as its distance from end of snout, shorter than parietals; two preoculars, upper much the largest; two postoculars, subequal; temporals, 242; supralabials, 7-8, only fourth bordering orbit; infralabials eight (nine) only three touching small anterior chinshields which are about half as large as second pair; latter separated posteriorly by a scale; four paired scales between chinshields and first ventral; a small cuneate scale on lip between third and fourth infralabial. Scalerows: 34 on occiput, 28 on neck, 42 middle of body; 34 before vent. Head scales with very numerous fine spinelike elevations; dorsal scales with a keel terminating in a slightly elevated spine; keels forming distinct straight lines on body; ventrals, anteriorly, may have six keels and/or tubercles arranged three or more on the side (the outer usually longest); more posteriorly tubercles reduced to two. Four preanal scales, two outer ones largest; two other scales narrowly excluded from vent (at one side one scale touches vent at a point); median preanal preceded by a pair of equally large scales; three ventrals preceding these divided; eye small, its vertical diameter less than its distance from lip.

Color in life: Deep bluish gray covering median 15 scalerows (occasionally part of adjoining rows); remainder of body cream-white. Top of head black; supralabials cream the adjoining parts of scales above, cream with a slight pigmentation; chin cream; a

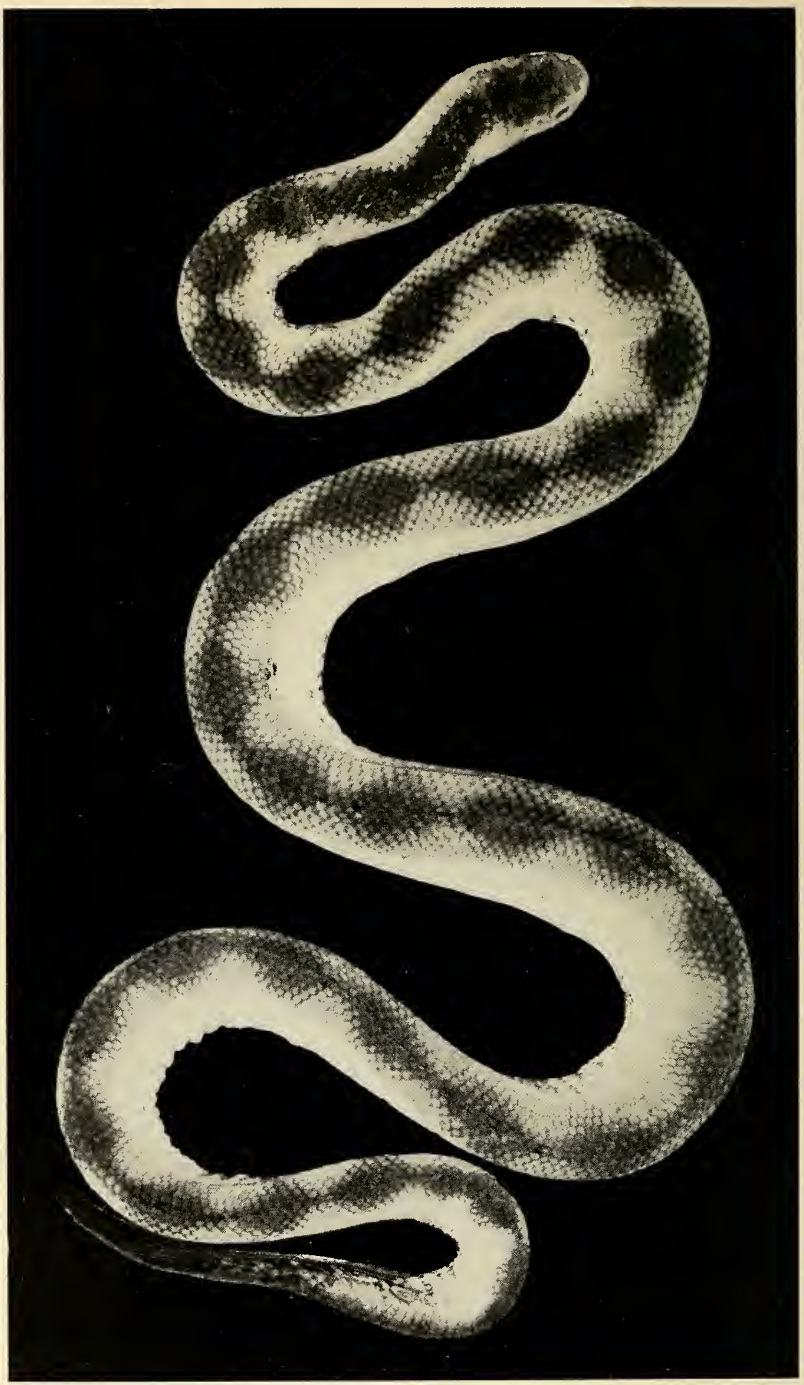

FIG. 103. *Praescutata viperina* (Schmidt). No. 34622, Songkhla, Songkhla province, southern Thailand. Actual total length, 528 mm.; tail, 58 mm.

series of 31 black rhombs on body, last one reaching vent; one at base of tail; remainder of tail uniformly black. Two fangs followed, after a well-marked diastema, by five teeth.

Measurements in mm.: Total length, 668; tail, 78; head-width, 13.1; head-length, 23.

Table of data on *Praescutata viperina*

NUMBER	583	501	481	502	338
Sex	♂	♂	♀	♂yg.	♂
Length total	730	668	649	470	388
Length tail	77	78	75	53	61
Head-width	14.8	13.1	15	12	13
Head-length	25	23	21	18	18
Ventrals	265	236	267	224	242
Subcaudals	50	48	48	39	50
Neck scalerows	34	28	31	29	32
Middle body, scalerows	49	42	46	40	40
Before vent, scalerows	40	34	38	33	38
Body bands	34	31	32	33	35
Preoculars	1	2	2	1–2	2
Postoculars	2	2	2–3	2–2	2
Supralabials border eye	4th	4th	4th	4th	4th
Supralabials	7–7	7–8	8–8	8–8	7–8
Infralabials	8–8	8–9	8–9	8–8	8–8
Temporals	2+3 2+3	2+2 2+2	2+3 2+3	2+3 2+4	2+3 2+3
Intercalated scales on lower lip	1–1	1–1	2–2	0–0	1–1

Variation: The species varies from 226 to 274 in ventral count, and from 37 to 50 in the number of scalerows around body; 27 to 34 in scalerows around neck. In Thai specimens scale variation are as follows (means): Ventrals, females, 232; males, 247; scalerows on neck and body, females 28 to 40, of males 31 to 45 (based on counts published by M. Smith).

Malcolm Smith's description states that there are 7-9 supralabials with the third to fifth bordering eye (sometimes only two scales); usually only a single anterior temporal but sometimes two or three; one preocular (rarely two), and one or two postoculars.

Three color patterns are known:

1. Gray above, white below meeting on side with a fairly clear line of demarcation.

2. Gray above with 25-35 black rhomboids usually more or less confluent (the common form).

3. A completely banded form (three specimens, two from India, one from Borneo known).

Distribution: Only the first and second form have been taken along Thai coasts. The second form may lose the rhombs in old specimens.

A specimen having only 181 ventrals was taken at Koh Kong, Gulf of Thailand. Smith (1943) regards it as an anomaly, since a second specimen from the same locality has 232 and each has 27 scales about the neck, and 41 scalerows about body.

The species is known in the Bay of Bengal Persian Gulf, Indian Ocean, the Java Sea, and the coasts of China, Cochinchina, Java, and Borneo. The longest specimen reported is 925 mm. in length.

Nos. 502 and 338 resemble each other very much. The dorsal coloration is a very light gray with 33 black rhombs touching each other for the most part on the middorsal line. In each, half of the tail is black. The black rhombs encroach slightly on the white of side and venter.

The length of No. 502 is 470 mm.; the tail 53 mm.; there are 224 ventrals, and 39 subcaudals. The scale formula is: 29, 40, 33.

Genus *Enhydrina* Gray

Enhydrina Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 47 (type of genus, *valakadien* = *schistosa* Daudin).

Diagnosis: Maxillary bone not extending forward as far as the palatine; poison-fangs followed after an interval by three or four maxillary teeth. Body elongate, very strongly compressed posteriorly; scales imbricate or subimbricate in 49-66 rows on thickest part of body; ventrals small, distinct; head scales entire; nasals in contact, nostrils dorsal; mental very narrow, hidden in a mental groove.

Only a single species known. It is distributed along the southern Asiatic coasts from Persia to Cochin China, and south to the Australian coasts.

Enhydrina schistosa Daudin

(Fig. 104)

Hydrophis schistosus Daudin, Histoire naturelle générale et particulière des reptiles, vol. 7, 1803, p. 386 (based on Russell, Indian Serpents, vol. 2, pl. 10) (type-locality Tranquebar, Coromandel Coast of India); Schlegel, Essai sur la physionomie des serpents, vol. 2, p. 500, pl. 18; Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, p. 1344; Fischer, Abh. naturw. Ver. Hamburg, vol. 3, 1856, p. 48; Jan and Sordelli, Iconographie, générale des ophidiens, pt. 41, 1872, pl. 2.

Pelamis schistosus: Merrem, Tentamen systematis amphibiorum, 1820, p. 139.

Hydrus schistosus: Cantor, Catalogue of reptiles inhabiting the Malayan Peninsula and islands, 1847, p. 132.

Enhydrina schistosa: Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 213; Anderson, Proc. Zool. Soc. London, 1871, p. 193; M. Smith, Monograph of the sea-snakes (Hydrophiidae) 1926, pp. 36-40, fig. 17; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 35; Bull. Raffles Mus., no. 3, 1930, pp. 73-74; The fauna of British India including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes; 1943, pp. 449-450, figs. 144-145; Bourret, Les serpents marins Indochine Française, 1936, p. 347; Tweedie, The snakes of Malaya, 1954, pp. 104-105, fig. 25; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1163.

Hydrus valakadyn Boie, Isis, 1827, p. 554 (Based on Russell, An account of Indian serpents . . . pl. 11; Mocquard, Les reptiles de l'Indo-Chine, 1907, p. 52.

Enhydrina valakadyen: Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 48; Stoliczka, Journ. Asiat. Soc. Bengal, 1872, p. 91.

Enhydrina valakadien: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 302-303; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 193; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 406; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, March 1915, pp. 177, 214; *ibid.* no. 4, Dec. 1915, p. 248 (Klong Yai, Trad, Thailand); Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 174).

Enhydrina valakadyn: Stejneger, U. S. Nat. Mus. Bull., 58, 1907, p. 437, pl. 25; Wall, Mem. Asiat. Soc. Bengal, vol. 2, (8), 1909, p. 191; M. Smith, Journ. Federated Malay States Mus., vol. 10, no. 1, July, 1920, pp. 30-32, 60; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 221; Wall, Ophidia Taprobanica or the snakes of Ceylon, 1921, p. 401, fig.

Disteira russelli Fitzinger, Isis, 1827, p. 733, (based on Russell, An account of Indian serpents, pl. 11).

Hydrophis bengalensis Gray, Zoological miscellany, 1842, p. 62 (type-locality, Bengal).

Enhydrina bengalensis: Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 48; Günther, The reptiles of British India, 1864, p. 381; Fayrer, Thanatophidia of India, 1874, col. pl. 18; Murray, The vertebrate zoology of Sind, 1884, p. 396.

Thalassophis werneri Schmidt, Abh. naturw. Ver. Hamburg, vol. 2 (2), 1852, p. 85, pl. 6.

Hydrophis subfasciata Gray, Zoological Miscellany, 1842, p. 62 (type-locality, Bengal).

Diagnosis: One of the largest sea-snakes (1400 mm.). Head scales complete; mental scale hidden in a groove; chinshields not or poorly developed; scales imbricate or subimbricate; ventrals distinct, narrow; scalerows, 49-66; poison-fangs followed by three or four teeth; nasals long, narrowed anteriorly; frontal small.

Description of species (from No. 34543 Songkhla): Rostral somewhat beaklike, small, projecting downward below level of supralabials, a little higher than wide, not or scarcely visible from above; nasals large, angular in shape, pointed anteriorly, nostrils on dorsal side of snout; prefrontals moderate, nearly as large as frontal; frontal pointed behind, very much shorter than its distance from end of snout, much shorter than parietals, slightly

FIG. 104. *Enhydrina schistosa* (Daudin). No. 287, Songkhla, Songkhla province. Actual total length, 880 mm.; tail, 115 mm.

wider than supraoculars; internal faces of parietals with short entrant sutures. Supralabials eight (nine) fourth bordering eye; fifth smallest, last vertically placed; mental very small, elongate, in a groove between first infralabials; typical chinshields cannot be distinguished; first infralabials not in contact; infralabials, 11-11; one pre- and one postocular; two anterior temporals, upper largest.

Scalerow-formula: 45, 54, 38, scales hexagonal, with short keels. Ventrals, 291, subcaudals, 47; six small scales border front of vent. There are three grooved maxillary teeth following the two grooved fangs.

Color: The dorsal twenty scalerows of body, top of head and entire tail, dark slate-gray; remainder yellowish cream; posterior supralabials and lower part of temporals cream; anterior supralabials dark; cream to white on venter.

Measurements in mm.: Total length, 1282; tail, 144; depth of tail, 29; greatest depth of body, 64; width of head, 25; length of head, 40.

Variation: The described specimen when placed under clear liquid has an indication of darker bands on the posterior part of the body, that are not or scarcely visible otherwise. Young specimens have from 43 to 49 dim dorsal spots on body, which posteriorly extend down on the side and surround the body. Many of the younger specimens are greenish or olive above, the spots a little darker, the intervening areas yellowish and on sides distinctly greenish yellow. One young male is blue-gray above and almost paper white on the sides and venter. The tail is dark.

Of the snakes of this species taken at Songkhla about one half of the specimens have two postoculars. The first pair of chinshields are evident in some specimens but they are widely separated, by from three to five scales. In an occasional specimen a small "cuneate" scale appears on the oral border between the third and fourth supralabials. In none does the second labial touch the prefrontal. There are two anterior temporals usually present. The known variation in the number of ventrals is from 239 to 354, but it is considerably less on the average in Thai specimens. When separated according to sex they vary: 236 to 276 ♀ , 243 to 292 ♂ . Subcaudals, 37 to 50 ♀ ; 37 to 56 ♂ .

M. Smith reports three specimens from Thailand having a broad black irregular band along either side of the body, a narrow ventral band, and irregular black dorsal spots.

Distribution: Found everywhere in Thai seas. It is said, that second only to *Pelamis platurus* it is the most widely spread species of the sea snakes known.

Remarks: This large species is potentially dangerous to man. Often when picked up by the tail the snake makes a definite effort to strike. Experiments with the venom show it to be proportionally more deadly than that of the cobra, producing death in a few minutes when injected into small animals. However no bites for human victims have been recorded to my knowledge.

These serpents grow to a length of 1400 mm. They have on occasion been found in fresh water many miles from the sea.

Genus *Acalyptophis* Boulenger

Acalyptus Duméril, Mem. Acad. Sci. Paris, vol. 23, 1853, p. 522 (type species *peronii*), (*non* Schoenheer).

Acalyptophis Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 269 (substitute name for *Acalyptus*).

Diagnosis: Maxillary bone longer than lower aspect of ectopterygoid; not extending as far forward as palatine; poison-fangs followed after an interval by from five to eight teeth; nasals divided, the nostril chiefly in outer nasal scale; scales subimbricate; ventrals smooth triangular, smaller than adjoining scales.

Only a single species known.

Acalyptophis peronii (Duméril)

(Fig. 105)

Acalyptus peronii A. M. C. Duméril, Mem. Acad. Sci. Paris, vol. 23, 1853, p. 522 (type-locality, ? "Nouvelle Holland").

Acalyptus superciliosus vel Peroni A. M. C. Duméril, Bibron and A. Duméril, Erpétologie générale . , . vol. 7, pt. 2, 1854, pp. 1341-1347; Günther, The reptiles of British India, 1864, p. 359.

Acalyptus superciliosus: Günther, The reptiles of British India, 1864, p. 359; Jan and Sordelli, Iconographie générale des ofidiens, vol. 3, livr. 40, May, 1872, p. 4, pl. 2, fig. 2 (drawing does not show the spinose appearance of head-scales).

Acalyptophis peronii: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 269-270; M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 102-103, 2 figs.

Diagnosis: Nasal scales in contact; frontal and parietal scales broken up more or less; head short, of moderate size; preoculars one or two, postoculars three or four; 19-23 scalerows on neck, 23-29 on body, scales feebly imbricate; ventrals smaller than adjoining scales and lacking a keel or tubercle. Some head scales spinose.

Description of species (from C.U. No. 510c, from Gulf of Siam): Thick-bodied snakes the width of head (11 mm.) less than one

third of greatest width of body (36 mm.); height of tail, 28 mm.; rostral about one and one-half times as wide as high, slightly visible above; nasals divided, valvular nostril in small outer portion, barely separated from prefrontals; latter scales about as long as wide; frontal broken into seven scales; parietals broken into subequal scales scarcely distinguishable from occipital scales; one preocular; supraocular rather large, spinose on outer border; three postoculars, two upper ones raised into a posterior spine; two to three rows of temporals; seven supralabials, third largest, third and fourth bordering orbit; nine (ten) infralabials, fourth separated from labial border by two (or one) small scales, last two infralabials small;

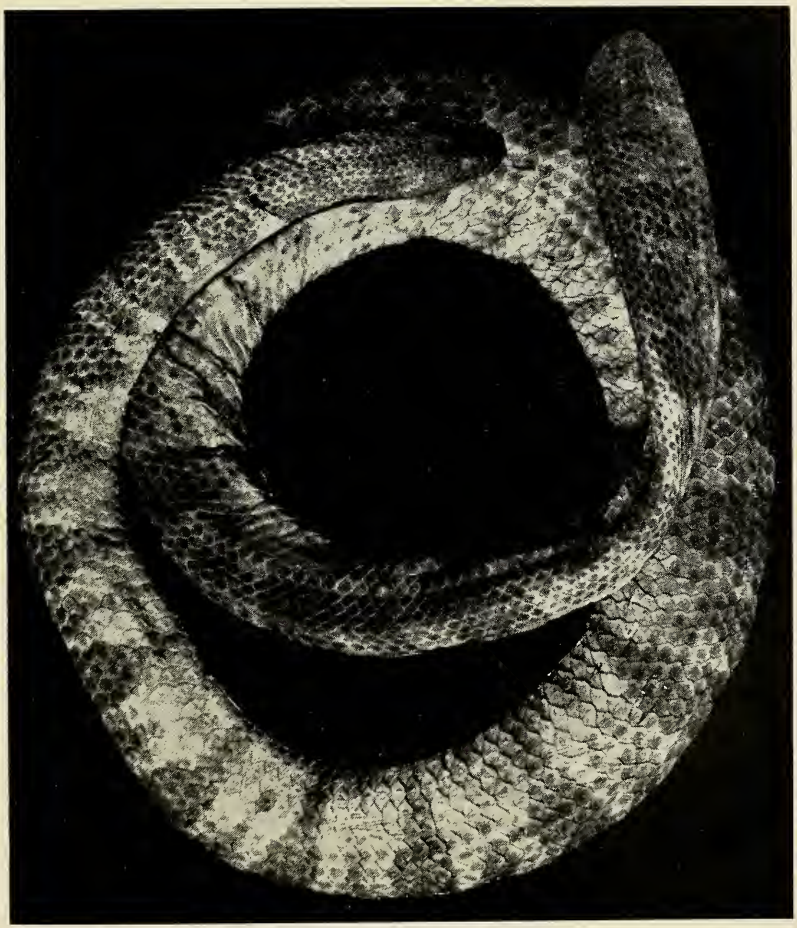

FIG. 105. *Acalyptophis peronii* (Duméril). C.U. No. 510c, Gulf of Siam. Actual total length, 861 mm.; tail, 97 mm.

two pairs of chinshields, anterior partially separating second pair; three infralabials border first pair; about seven paired scales between second chinshields and first ventral.

Scalerow-formula: 30 (occipital), 21, 26, 28; all scales (except ventrals) with a short longitudinal tubercle or keel. Ventrals, 196; subcaudals, 37; three small paired preanals; one enlarged lateral anal scale.

Color: Above gray with a series of transverse blotches of grayish black, wide (5 scales wide) on middorsal line narrowing on sides and venter to a width of two scales; there are indistinct dark blotches between bands, usually separated from a narrow ventral dark bar (dark centers on light scales), usually two scales wide.

Measurements in mm.: Total length, 861; tail, 97; width of head, 21; length of head, 26; height of tail, 28.

Variation: Ventral counts vary from 142 to 206. There may be six or seven supralabials but third and fourth border orbit; scalerows on neck vary between 19 and 23 rows; on middle of body from 23 to 29.

The spinelike condition of the scales about the eye and nostril is more evident in old adults.

Distribution: This is the first record of the species in the Gulf of Siam. It has been reported from Hong Kong, Torres straits and the Australian coasts.

It is regarded as a rare snake.

Genus *Thalassophis* Schmidt

Thalassophis Schmidt, Abh. naturw. Ver. Hamburg, vol. 2, 1852, p. 75 (*part.*) (type of genus, *anomalus*).

Diagnosis: Maxillary bone not reaching forward as far as palatine; poison-fangs followed after an interval by five teeth; headshields more or less broken up; nostrils superolateral; a pair of internasals usually present, separating nasals; body short, stout; scales juxtaposed in 31 to 35 rows; ventrals distinct, not or scarcely larger than adjacent scales (after M. Smith).

Only a single species known.

Thalassophis anomalus (Schmidt)

Thalassophis anomala Schmidt, Abh. naturw. Ver. Hamburg, vol. 2, 1852, p. 81, col. pl. 4 (type-locality, Java).

Hydrophis anomala: Fischer, Abh. naturw. Ver. Hamburg, vol. 3, 1856, p. 58; Günther, Reptiles of British India, 1864, p. 374; Jan and Sordelli, Iconographie générale des ophidiens, pt. 40, 1872, pl. 4.

Thalassophis anomalus: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 269; Wall, Mem. Asiat. Soc. Bengal, vol. 2, (8), 1909, p. 244; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 176, pl. —; Journ. Federated States Mus., vol. 10, 1920, p. 29; Ouwens, Giftslang. Nederlandisch Oost-India, 1916, p. 14, col. pl. 2; de Rooij, The reptilia of the Indo-Australian Archipelago, vol. 2, Ophidia; 1917, p. 223, fig. 86; M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 104-105, fig. 30; Bourret, Les serpents marins Indochine Française, 1935, p. 50; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 466-467 (Chanthaburi, Hua Hin); Tweedie, The snakes of Malaya, 1954, pp. 110-111; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1163-1164, fig. 33.

Diagnosis: A moderate-sized snake. Poison-fangs followed after a diastema by five maxillary teeth. Head-shields more or less broken up, especially rostral; a pair of internasals usually present, separating nasals. Scalerows, 31-35, juxtaposed, strongly keeled. Ventrals distinct but about as small as adjoining scales.

Description of species: Head short, body stout; rostral divided into four or five pieces; a pair of elongated internasals separating nasals; frontal small, variable in size, sometimes partially or completely divided; one preocular, one or two postoculars; temporals small, scarcely differentiated from body scales, usually 2 + 3 or 3 + 3; seven or eight supralabials, second normally in contact with prefrontal, the third, fourth, and fifth bordering orbit; four infralabials border two pairs of chinshields, of which second pair smaller than first and separated by small scales.

Scalerows: 27-30 on neck, 31-35 on body; posterior scales hexagonal in shape as broad or broader than long, juxtaposed and strongly keeled. Ventrals, 201 to 256, scarcely if any wider than adjacent scales, bicarinate; preanal shields feebly enlarged.

Color in life: Pale gray above, whitish below with from 30-36 dark dorsal bars broader than their interspaces and often connected vertebrally, tapering to a point on sides, or continued as narrow bands across venter; young may have a pale mark across snout extending backwards along either side of head.

Measurements in mm.: Male, total length, 810; tail, 19. Female, total length, 755; tail, 85 (from M. Smith).

Variation: The number of ventral scales varies considerably, the specimens from the Gulf of Siam having a higher average (241) than those from the East Indies (230).

Distribution: The species is known in the northern part of the Gulf of Siam and the coast of the southeastern part of Thailand and Cambodia. Elsewhere it is known from Borneo, Java, Sumatra and the Moluccas.

The distribution is rather unusual for a sea-snake since it is presumably absent from waters about the lower part of the Malay Peninsula.

Genus *Microcephalophis* Lesson

Microcephalophis Lesson, in Bélanger's, Voyage aux Indes orientales . . . 1834, p. 320 (type of genus, *Hydrus gracilis* Shaw).

Diagnosis: Maxillary bone longer than the ectopterygoid, extending as far as, or a little farther than palatine, concavity on its inner aspect very small; poison-fangs followed after a diastema by five or six teeth. Head very small, head shields regular. Nasal scutes in contact; body especially slender anteriorly, much larger posteriorly; ventrals small entire anteriorly or divided by a groove.

This genus is distributed on the Asiatic coast from the Persian Gulf to Hong Kong, occurring also in the Indo-Australian Archipelago and along the Australian coast. Two species, one with two recognized subspecies, are known. Only a single form of the latter species occurs along the coasts of Thailand.

Microcephalophis gracilis (Shaw)

Hydrus gracilis Shaw, General zoology, vol. 3, 1802, p. 560 (the type-locality unknown).

Microcephalophis gracilis gracilis (Shaw)

(Figs. 106, 107)

Disteria gracilis: Fitzinger, Neue Classification des Reptiles, 1826, p. 55; Stejneger, Herpetology of Japan, Bull. U. S. Nat. Mus., no. 58, 1907, pp. 427-428.

Distira gracilis: Wall, Mem. Asiat. Soc. Bengal, vol. 2 (8), 1909, p. 198, fig.

Microcephalophis gracilis: Lesson, in Bélanger, Voyage aux Indes-Orientales . . . 1834, p. 321, col. pl. 3; Gray, Catalogue of the snakes in the collection of the British Museum, 1849, p. 46; Wall, Snakes of Ceylon . . . 1921, pp. 325-330, fig. 62; M. Smith, Monograph of the sea-snakes (Hydrophiidae), Nov. 27, 1926, pp. 121-123, fig. 34; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 272-273, figs. 150-151; Kennady, Journ. Bombay Nat. Hist. Soc., 1937, p. 748; M. Smith, The sea-snakes Hydrophiidae in Dana Report No. 8, Copenhagen, 1935, p. 8; Bourret, Serpents marins de l'Indochine Française, 1935, p. 60; Les serpents de l'Indochine, 1936, p. 378, fig.; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, p. 173; Smith, Bull. Raffles Mus., no. 3, 1930, pp. 86-87 (Singapore, Bay of Pattani); Tweedie, Snakes of Malaya, 1954, p. 112; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, p. 1045.

Liopola gracilis: Gray, Zoological miscellany, 1842, p. 60.

Hydrophis Kadell-Nagam Boie, *in* Boie, Isis, 1827, p. 554 (Based on Russell's Indian Serpents, vol. 2, pl. 13.

Hydrophis gracilis: Duméril and Bibron, Erpétologie générale . . . vol. 7, 1854, pp. 1352-1354; Günther, The reptiles of British India, 1864, p. 373; Murray, Vertebrate zoology of Sind, 1884, p. 395; Anderson, Journ. Linn. Soc., vol. 21, 1889, p. 348; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 280-281; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 191-192; Sclater, List of the snakes in the Indian Museum, 1891, p. 64; Wall, Mem. Asiat. Soc. Bengal, vol. 1, 1906, p. 283; de Rooij, Reptiles of the Indo-Australian Archipelago, Ophidia, 1917, p. 228; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 26-27, 55.

Hydrophis (*Microcephalophis*) *gracilis:* Boettger, Offenbach. Ver. Naturk., 1888, p. 90.

Hydrophis leprogaster Duméril and Bibron, in Fischer's Abhandl. naturw. ver Hamburg, vol. 3, 1856, p. 53.

Hydrophis microcephala: Jan and Sordelli, Iconographie générale des ophidiens, 1872, pt. 41, pl. 5.

Hydrophis guentheri Murray, Vertebrate zoology of Sind, 1884, p. 385.

Diagnosis: Head very small, anterior part of body very slender, cylindrical, posterior part much larger, strongly compressed, four to five times diameter of neck; prefrontal touching second but not third supralabial; scalerows, 17-19 on neck; snout projects beyond mouth; rostral somewhat inclined towards a horizontal position; a large anterior temporal followed by an equally large posterior temporal; no cuneate scales on oral border between infralabials.

Description of species (from No. 318, Songkhla, Thailand): Rostral a little higher than wide, rounding rather than angular behind, broadly visible, inclined towards a horizontal position; nasals large, broadly in contact, nostril in extreme outer posterior corner without a suture from nostril to labial; prefrontals about half area of nasals, a little larger than frontal; frontal distinctly narrower than the broad supraoculars, equal to its distance to anterior level of nostrils, about half length of parietals; one pre- and one postocular, both reaching much above eye level; diameter of eye equal or slightly larger than its distance from mouth; a large anterior temporal followed by another about equally as large; supralabials six, second touches prefrontal; third and fourth border orbit, sixth bordering upper curve of mouth; infralabials eight, five anterior large, followed by two smaller (one on one side), first four (or three) touch first pair of chinshields; each of first pair of chinshields nearly as large as combined second pair; seven scales between chinshields and first ventrals.

Scalerows: 21, 33, 28, the dorsal and lateral scales each with a small tubercle. Ventrals with two large tubercles; anterior ventrals undivided, a little larger than adjoining lateral scales, then more posteriorly they become divided by a median groove and from then on they are paired side by side or alternating with one

FIG. 106. *Microcephalophis gracilis* (Shaw). No. 579, Songkhla, Songkhla province, southern Thailand. Actual total length, 613 mm.; tail, 52 mm.

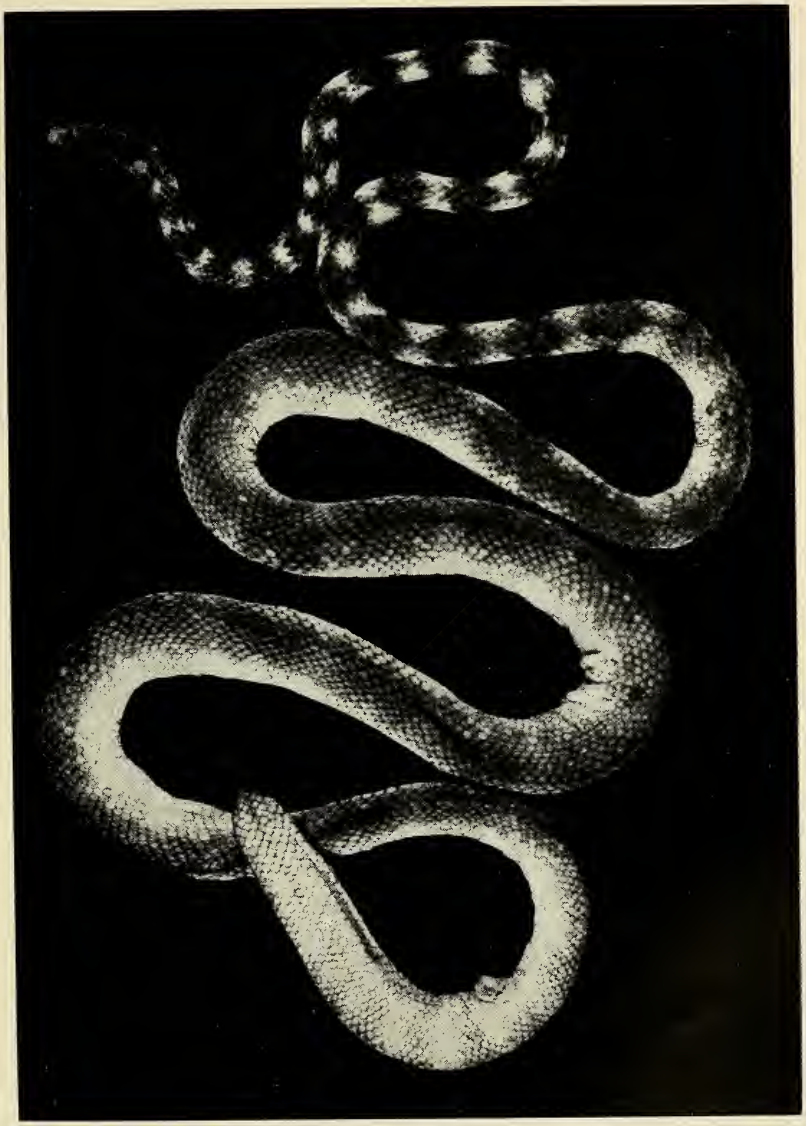

FIG. 107. *Microcephalophis gracilis* (Shaw). No. 317, Songkhla, Songkhla province, southern Thailand. Actual total length, 693 mm.; tail, 60 mm. (color variant).

another. This division begins at eleventh ventral; after the 130th all are divided, and groups of paired scales alternate with those where the pair alternates with one another.

Ventrals, 311; anals, slightly enlarged, median pair largest with three or two on each side; subcaudals, 36. Ventrals and subcaudals have the largest spines or tubercles.

Color in life: Above grayish, many scales having a lighter gray center. Anteriorly series of lateral cream or ivory spots present that may or may not join together on back; latter two thirds of body practically uniform, sides and venter becoming ivory-white as is the side of tail. Chin and head blackish with olive clouding on anterior head scales; neck rather dirty white.

Measurements in mm.: Total length, 452; tail, 64; head-width, 6; head-length, 13; height of body, 22; depth of tail, 15.

Variation: The attached table shows variation in five specimens from the same locality (Songkhla).

Variation: The younger specimens have the bands on body moderately distinct; these number from 52 to 58 in males; 61 in one female; in two of the older specimens the bands lack definition and cannot be counted. In younger specimens the head and the anterior part of the body are deep black, in older specimens there is some lighter color in evidence.

One specimen had the second supralabial excluded from the prefrontal. The first pair of infralabials are sometimes as large as

Table of data on *Microcephalophis gracilis*

NUMBER	318	572	559	579	317
Sex	♂	♂	♀	♂	♂
Total length	752	705	820	613	693
Tail	64	61	62	52	60
Head, length	13	11	12.2	9.8	11
Head, width	6	4	5	4.5	5
Height of body	22	15.5	23	14	19
Preocular	1–1	1–1	1–1	1–1	1–1
Postocular	1–1	1–1	1–1	1–1	1–1
Temporals	1+1	1+1	1+1	1+1	1+1
Supralabials	6–6	6–6	6–6	6–6	6–6
Infralabials	8–8	8–8	8–8	8–8	8–8
Scalerows, neck	21	21	21	19	19
Scalerows, widest part	33	33	33	33	33
Ventrals	311	295	362	302	296
Subcaudals	36	37	41	38	34
Bands, body and tail	dim	dim	61	58	52

the combined chinshields, sometimes a little smaller. The known variation in ventral counts is from 220 to 362, the average for Thai specimens being 308.

Remarks: As yet this species is not very well known from Thai waters. Malcolm Smith reports but two specimens, I have but five. Three of my specimens have 21 scalerows around the body. With sufficient material it may be possible to define a race having a greater number of ventrals, and a very small frontal scale. Other differences may obtain. These snakes, because of the minute head, and fangs with a dimension of one-half millimeter in length, cannot be regarded as being dangerous to man.

Distribution: In Thailand the species occurs along the coast bordering the Gulf of Siam. I have no reports from the Bay of Bengal.

Genus *Pelamis*

Pelamis platurus (Linnaeus)

(Fig. 108)

Anguis platurus Linnaeus, Systema Naturae, 12th Ed., 1766, p. 391 (type-locality unknown) (see Andersson and Linnaeus, *loc. cit.*).

Hydrophis platura: Latreille, Histoire Naturelle des reptiles, vol. 4, 1802, p. 197.

Hydrus platurus: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed. vol. 3, 1896, p. 267; Stejneger, Bull. U. S. Nat. Mus., no. 58, 1907, pp. 439-442, figs. 355-357; Wall, Mem. Asiat. Soc. Bengal, vol. 2, (8), 1909, p. 248; Ophidia Taprobanica or the snakes of Ceylon, 1921, pp. 420-426, fig. 80; de Rooij, Snakes of the Indo-Australian Archipelago vol. 2, Ophidia; 1917, pp. 224-225, fig. 88; M. Smith, Journ. Federated States Mus., vol. 10, 1920, p. 5; Lord, Proc. Royal Soc. Tasmania, 1919, p. 22; Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 172.

Pelamis platurus: Stoliczka, Proc. Asiat. Soc. Bengal, 1872, p. 92; M. Smith, Monograph on the sea-snakes (Hydrophiidae) 1926, p. 116, fig.; Bull. Raffles Mus., no.3, 1930, p. 85; Bourret, Les serpents marins de l'Indochine Française 1935, p. 57; Tweedie, Snakes of Malaya, 1954, pp. 112-113. H. Smith and Taylor, U. S. Nat. Mus. Bull., no. 187, 1945, pp. 176-177; Taylor, Univ. Kansas Sci. Bull., vol. 33, pt. 2, 1950, pp. 591-592.

Pelamydrus platurus: Stejneger, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 111; Taylor, Snakes of the Philippine Islands, 1922, p. 253.

Hydrus bicolor: Schneider, Historiae amphibiorum naturalis et literariae. fasc. primus, 1799, p. 242.

Pelamis bicolor: Daudin, Histoire naturelle générale et particulière des reptiles, vol. 7, 1803, p. 366; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 35, 36, 63; Gray, Catalogue of the snakes in the British Museum, 1849, p. 41; Cantor, Catalogue of the reptiles inhabiting the Malay Peninsula and Islands, reprinted from Journ. Asiat. Soc. Bengal., vol. 16, pt. 2, p. 134; Duméril, Bibron, and Duméril, Erpétologie générale, . . . vol. 7, pp. 1335-1338; Günther, Reptiles of British India, 1864, p. 382; Krefft, The snakes of Australia, 1869, p. 98, pl. 12; Strauch, Mem. Acad. Sci. Petersburg, vol. 21, 1873, p. 199; Fayrer, Thanatophidia of India, 1874, color pl. 17; Hilgendorf, Mitth. Deutsch Ges.

Ost-Asiens, vol. 1, 1876, p. 30; Peters and Doria, Ann. Mus. Civ. Genova, vol. 13, 1878, p. 416; Murray, Vertebrate zoology of Sind, 1883, p. 397.

Hydrophis (Pelamis) bicolor: Fischer, Abh. naturw. Ver. Hamburg, vol. 3, 1856, p. 61.

Hydrophis bicolor: Jan and Sordelli, Iconographie générale des Ofidiens, pt. 40, pls. 2, 3; Okada, Catalogue of the Vertebrates of Japan, 1891, p. 69.

Pelamis schneideri Rafinesque, Amer. Month. Mag., vol. 1, 1817, p. 437 (substitute name for *bicolor*).

Hydrophis pelamis: Schlegel, Essai sur la physionomie des serpents, vol. 1, 1837, (Atlas, pl. 18); Fauna Japonica, 1837, p. 90, pl. 8; Boettger, Ver. Nat. Offenbach, vols. 17-18, Ber., 1878, p. 8.

Pelamis ornata: Gray, Zoological miscellany, 1842, p. 60; Catalogue of the snakes in the collection of the British Museum, 1849, p. 43.

Hydrus platurus ornatus: Barbour, Mem. Mus. Comp. Zool. Harvard Col., vol. 44, 1912, p. 129.

Pelamis bicolor variegata Duméril and Bibron, Erpétologie générale . . . vol. 7, 1854, p. 1337; Jan. Iconographie générale des ophidiens, pt. 40, 1872, pl. 3. (Figured in Russell, vol. 2, pl. 12) (type-locality, Celebes, near Macassar).

Pelamis bicolor sinuata Duméril, Bibron, and Duméril, Erpétologie générale, vol. 7, 1854, p. 1338 (type-locality unknown).

Hydrophis (Pelamis) bicolor alternans Fischer, Abh. naturw. Ver. Hamburg, vol. 3, 1856, p. 63 (substitute name for *variegata*).

Hydrophis bicolor maculata Jan and Sordelli, Iconographie générale des ophidiens, livr. 40, 1872, pl. 3, fig. 1, (type-locality, Mer des Indes).

Diagnosis: A medium-sized sea-snake reaching about 900 mm. in length; head somewhat flattened with a narrow elongate snout; body much compressed posteriorly; one or two preoculars, two or three postoculars; a single pair of chinshields developed; 49-67 scalerows, scales more or less quadrangular, lower rows with one or two tubercles; ventrals, 264-406, usually divided mesially, sometimes almost indistinguishable from body scales. Uniform black above, yellow-olive or cream on sides, variable.

Description of species (from No. 503 ♂, Songkhla): Rostral small, much wider than high, scarcely larger than first labial, and scarcely visible from above; nasals large, in contact for their entire length; nostrils dorsal; prefrontals large, more than two third area of nasals; frontal a little longer than its distance from end of snout, as long as parietals, sides subparallel; parietals partially cut by suture; a large preocular, much longer than high; diameter of eye double its distance from mouth; three (two) postoculars, two anterior temporals, the arrangement on one side is $\frac{1}{3} + 2$; on other $\frac{1}{2} + 3$; supralabials eight, second largest, in contact with prefrontal, fourth borders eye; no suboculars; sixth and seventh supra-

FIG. 108. *Pelamis platurus* (Linnaeus). No. 3415 young, Songkhla, Songkhla province, Thailand. Actual total length, 212 mm.; tail, 27 mm.

labials smallest; infralabials eleven, two (or three) bordering a pair of chinshields which are separated by a scale; second pair of chinshields not differentiated.

Scalerows: 44 occiput, 41 neck, 49 widest part of body, 35 before vent; scales generally subquadrangular, dorsals smooth, laterals with one or, more frequently, two tubercles toward posterior part of body. Ventrals, 295 (scales counted to chinshields since anterior ventrals are not differentiated) two enlarged anals separated by a median smaller scale; subcaudals, 46.

Color: Top of head, and median 12 scalerows (10 posteriorly) deep black; remainder of body bistre to yellowish olive, each scale with a lighter center. A short distance before level of vent, the black color of the back begins to separate into spots, and these sometimes become connected with other spots, while on mid-dorsal line the lighter color tending to separate into spots; a black anal spot and two black spots on sides of tail. Chin, infralabials, and lower part of supralabials dirty indefinite gray.

Measurements in mm.: Total length, 384; tail, 50; width of head, 12.8; length of head, 23; depth of body, 18; depth of tail, 9.5.

Variation: This species has produced a large number of color forms that are usually regarded unworthy of recognition even as subspecies since several of these varieties may occur together. However Deraniyagala has recently recognized some ten color varieties occurring in the waters about Ceylon. All have been given names.

The scalerows on the body vary from 49 to 67 in number; the ventrals from 264 to 406.

I obtained a young specimen at Songkhla. In this the black dorsal stripe covers the six median scalerows and parts of the adjoining row (figured).

Distribution: The species is widely distributed from Possiet Bay, Siberia, south to Tasmania. Its presence on the west coast of the Western Hemisphere gives rise to the question of its manner of arrival there. I had the temerity to suggest that it was carried accidentally by the Spanish galleons to the Mexican Coast in historic times only to learn later that Dávila in 1504 reports it from Bahia de Culebras in Costa Rica, where it was common. The presence of the snake in Siberia suggests its adaptation to waters of lower temperature and at some time it most probably made its way around the Aleutian Islands perhaps during one of the interglacial periods when a milder climate obtained. The species occurs

on the Mexican Coast north, nearly to the boundary of the United States. None, however, to my knowledge has been taken in waters north of the United States boundary.

The species is present along the coasts of Thailand bordering the Gulf of Siam and perhaps as well everywhere in the Gulf. The species is known to maintain itself many miles from shore. Several specimens were collected by the Naga Expedition 1959-61 in waters of southeastern Asia on the surface of the water with dip nets. I have collected only a single coastal specimen along the shore.

Lapemis Gray

Lapemis Gray, Illustrations of Indian Zoology, vol. 2, 1935, color plate 87, fig. 2 (type of genus, *Lapemis curtus*).

Enhydris (*part.*) Merrem, Tentamen systematis amphiorum, 1820, p. 140.

Hydrophis (*part.*) Schlegel, Essai sur la physionomie des serpens, vol. 2, 1837, p. 488.

Diagnosis: Maxillary bone longer than lower aspect of ectopterygoid, extending forwards as far, or nearly as far, as palatine; poison-fangs followed after a diastema by from three to six teeth; nostrils superior; nasal shields in contact with one another; head large, body stout; scales hexagonal or quadrangular, juxtaposed, the scales of lowermost rows larger than others; ventrals small, usually distinct anteriorly, very small or absent posteriorly.

Of the two recognized species one occurs in the Gulf of Siam, where it is very common.

Lapemis hardwickii Gray

(Figs. 109, 110)

Lapemis hardwickii Gray, Illustrations of Indian Zoology, vol. 2, 1834, pl. 87, colored fig. (type-locality, India); Günther, The reptiles of British India, 1864, p. 380 ("several circumstances lead me to suppose that it [the type] was procured in Pinang"); Stejneger, Bull. U. S. Museum, no. 58, 1907, pp. 435-436, pl. 24; Longman, Mem. Queensland Mus., vol. 6, 1918, p. 41; Wall, Ophidia Taprobanica, or the snakes of Ceylon, 1921, pp. 416-420, fig. 78; M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 108-112, fig. 32 (skull); Bull. Raffles Mus., no. 3, 1930, pp. 84-85; Tweedie, The snakes of Malaya, 1954, p. 111; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1163, fig. 33 (Phet Buri province, Thailand).

Hydrophis hardwickii: Günther, Fauna of British India, 1864, p. 380, pl. 25; Müller, Verh. naturf. Ges. Basel, vol. 7, 1882, p. 170; Anderson, Journ. Linn. Soc., vol. 21, 1889, p. 348.

Enhydris curtus Laidlaw, Proc. Zool. Soc. London, 1901, p. 581 (*fide* M. Smith).

Enhydris hardwickii: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 301; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 193; Hanitsch, Reptiles of the Raffles Mus., 1897, p. 16; Mocquard, Les Reptiles de l'Indochine, 1907, p. 52; Wall, Mem. Asiat. Soc. Bengal, vol. 2, no. 8, 1909, p. 247, fig. and

pl. 9; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1915, p. 248; Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, pp. 785-787; Journ. Federated Malay States Mus., vol. 10, 1920, pp. 32-34; 62. Taylor, Snakes of the Philippines, 1922, p. 249, fig.; Ouwens, Giftsch. Ned. Oost-India, col. pl., 1916; de Rooij, The Reptilia of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 240, fig. 90.

Hydrophis pelamidoides Schlegel, Essai sur la physionomie des serpents, vol. 2, 1937, p. 512, pl. 18 (type-locality, Indian Seas); Fauna Japonica, reptiles, 1838, p. 91, pl. 9; Duméril, Bibron, and Duméril, Erpétologie générale . . . vol. 7, 1854, p. 1345; Jan and Sordelli, Iconographie générale des ophidiens, livr. 41, 1872, pl. 3.

H. (Pelamis) pelamidoides: Fischer, Abh. naturw. Ver. Hamburg, vol. 3, 1856, p. 64.

H. (Pelamis) pelamidoides annulata, ibid., p. 67, color pl. 3.

Lapemis loreatus Gray, Ann. Mag. Nat. Hist., vol. 9, 1843, p. 46 (type-locality Borneo).

Hydrophis loreatus: Günther, Reptiles of British India, 1864, p. 380; Peters and Doria, Ann. Mus. Civ. Genova, vol. 13, 1876, p. 416; Boettger, Zool. Anz., 1888, p. 396.

Hydrophis abbreviatus Jan, Elenco Syst. Ofid., 1863, p. 109; Jan and Sordelli, Iconographie générale des ophidiens, livr. 40, 1872, pl. 4 (type-locality, Manila).

Hydrophis brevis, Jan, Elenco Syst. Ofid., 1863 p. 109; Jan and Sordelli, Iconographie générale des ophidiens, 1872, livr. 40; pl. 5 (type-locality, Manila P. I.).

Diagnosis: A short, rather stout snake with relatively large head. Parietals entire; ventrals small anteriorly, very small or absent posteriorly; poison-fangs followed by from three to six teeth; scales quadrangular or hexagonal, juxtaposed; ventral scales largest; chinshields poorly developed and separated by small scales. Ventrals, 114-230. Greenish or yellowish olive, with 35-50 darker olive bands tapering to a point on sides.

Description of species (from No. 564, Songkhla): Rostral wider than high, visible from above only as a line; nasals large, broadly in contact; a suture from nostril to suture between first and second supralabials (absent on left side); prefrontals large, posterior part forming an angle between frontal and supraocular; frontal wider than supraoculars, slightly shorter than its distance from rostral, shorter than parietal; one preocular, one postocular; two anterior temporals followed by three (on left side three anterior); two temporals and parietal border postocular; supralabials seven, second divided leaving a large "loreal"; third and fourth border orbit; infralabials ten or eleven, two bordering first chinshield; second pair of chinshields slender, elongate; both pairs separated by small scales, and except for their relationship to infralabials scarcely discernible as such; fourth infralabial largest.

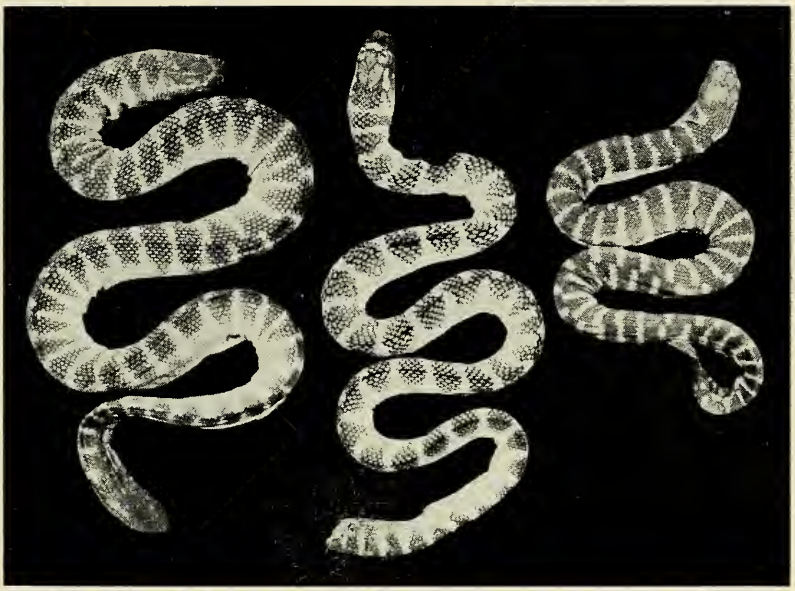

FIG. 109. *Lapemis hardwickii* Gray. Left figure, No. 34584, actual total length, 412 mm.; middle figure, No. 34659, length, 401 mm.; right figure, No. 34635, length, 290 mm. All from Songkhla, Songkhla province, southern Thailand.

Scalerows: 26 (neck), 27, 31, the scales quadrangular, those on venter much the largest, juxtaposed, smooth, for the most part; a few ventral rows with single small tubercles (or in old males, strong tubercles).

Ventrals cannot be counted with certainty since many are missing; count of transverse scalerows, 140; subcaudals, 40; outer anals enlarged, separated by a smaller median pair.

Color: Head blackish with some yellowish marks above eyes and across prefrontals; labials and chin blackish; body yellowish with dark olive bars across back terminating in a point on sides, narrowly separated dorsally, usually by only one transverse scalerow; 42 bars on body, seven on tail; lower part and terminus of tail black.

Variation: Variation in the head scales is considerable. A large proportion of the specimens have three anterior temporals; the sixth supralabials is normally small, but frequently fuses to a secondary temporal and borders the mouth as a large scale; often two postoculars are present.

FIG. 110. *Lapemis hardwickii* Gray. No. 34578, Songkhla, Songkhla province, southern Thailand. Actual total length, 694 mm.; tail, 70 mm.

The scales around neck vary in number between 23 and 33 in males, 27 and 35 in females; around the body, at about the middle, 25 to 37 in males, 33 to 41 in females. The range of ventrals is 114-186 in males; 141-230 in females.

The bars vary between 35 and 50 and rarely encircle the body completely; the bars rarely may unite to form a uniformly colored back. A ventral or lateral black stripe may be present.

Distribution: The species is common in the Gulf of Siam at least along the eastern side of the peninsula. It is seemingly less common about the shores of Indo-China. It is known to occur from Japan to Australia, and on the coasts of the larger islands of the Indo-Australian Archipelago and the Philippines.

Addenda: An unusual specimen No. 34636 from Songkhla is referred to this species. The median eight to ten scales are deep black with a series of 43 (44) lateral bars of dull greenish gray (frequently joined together low on sides), outlining bars of black which become narrow on the sides. A median ventral series of large spots sometimes extending nearly half way up on the sides is present.

The head, chin, and the ventral part of neck are black. The tail is black with only a trace of two bars near the base. The anal region is white. The scales of the head as well as those of the body conform in essential detail to the described specimen.

Certain variants from Songkhla are figured. Fig. 109.

Genus *Hydrophis* Latreille

Hydrophis Latreille, Histoire naturelle des reptiles, vol. 4, 1802, p. 193 (type of genus, *fasciatus*).

Diagnosis: Maxillary bone not extending forwards beyond palatine; poison-fangs followed by from one to 18 teeth. Head shields unbroken; nostrils dorsal, the nasals in contact with one another; scales imbricate, subimbricate, or juxtaposed, in 29-57 rows on thickest part of body. Ventrals very small but normally distinct throughout. Head large or small.

The genus is represented in waters adjacent to Thailand by at least eight species and subspecies.

KEY * TO THE THAI SPECIES OF *Hydrophis*

1. Scales distinctly imbricate throughout body; with more or less rounded tips posteriorly 2
   Scales quadrangular or hexagonal their posterior tips blunt or truncate, juxtaposed, or slightly subimbricate 3
2. Normally two anterior temporals, five to six maxillary teeth behind poison-fangs; scales about middle of body, 37-47; larger, reaching two meters in length; usually yellowish green to olive, banded with blackish; head medium, two unsegmented infralabials ..... *cyanocinctus*
   Normally a single anterior temporal; five to six maxillary teeth behind

* The size of head and neck in proportion to the greatest diameter of the body is a significant specific character in the sea-serpents. In the key the heads are described as from "large" to "small,"—"large" refering to species having the body one and a half to rarely twice diameter of neck; "medium," from about two to two and three fourths times, "small" two and a half to three, "very small" from three to four (or a little more) times diameter of neck. The actual width of the head of these four criteria in millimeters might be approximately 19-22, 14-20, 7-10, 5-6.

poison-fangs; scales about middle of body, 31 to 37; smaller, not or rarely reaching one and a half meters in length; head medium..... *klossi*

Eight to eighteen maxillary teeth behind poison-fangs; head large to small, 4

Five to six maxillary teeth behind poison-fangs, head very small..... 6

4. Head large, maxillary teeth, 10-13 behind poison-fangs; normally two anterior temporals; usually less than one meter in length; no small cuneate scales bordering oral margin; usually pale grayish or olivaceous with bars and spots..... *o. ornatus*

Head medium..... 5

5. Normally two anterior temporals; 14-18 maxillary teeth following poison-fangs; usually banded bluish-gray; usually less than a meter in length, *caerulescens*

Eight to ten maxillary teeth following the poison-fangs; usually a single anterior temporal; usually less than a meter in length..... *torquatus*

6. Five or six maxillary teeth behind poison-fangs; anterior part of body very slender; a single anterior temporal followed by an equally large secondary temporal, sometimes divided; two to four scales border parietals between temporals; a small cuneate scale on oral margin between third and fourth supralabials; head and anterior part of body shiny black; 39 to 49 scalerows at middle of body..... *fasciatus atriceps*

A single anterior temporal bordering or almost touching mouth, followed by a vertically divided temporal (rarely single); 37 to 45 scalerows at middle of body, grayish above, the anterior bands encircling body, posteriorly bands incomplete ventrally; four to seven scales bordering parietals between temporals..... *brookei*

(*Hydrophis mamillaris* is intentionally omitted from the key)

Hydrophis cyanocinctus Daudin

(Figs. 111, 112)

Hydrophis cyanocinctus * Daudin, Histoire naturelle des reptiles, vol. 7, 1803, p. 383 (type-locality, Sunderbunds *); Boettger, Ber. Offenb. Ver. Naturk, Band 26-28, 1888, p. 88; Fayrer, The Thanatophidia of India . . . 1874, p. 26, pl. 23; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 185-186; Wall, Journ. Bombay Soc. Nat. Hist., vol. 23, 1914, p. 375; *ibid.*, vol. 25, June, 1918, pp. 599, 600, 605, 754, with diagram; *ibid.*, vol. 26, 1919, p. 433, fig.; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, p. 8; Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 56-63, text fig. 20; pl. 1, fig. 4; Bull. Raffles Mus., no. 3, 1930, p. 77; Pope, Reptiles of China, 1935, p. 358; Bourret, Serpents marins Indochine Française, 1935, pp. 32-35, pl. 1, fig. F; pl. VI, fig. A; text fig. 6; Les serpents de l'Indochine, 1936, p. 353, fig.; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 454-456, figs. 146-147; Tweedie, The snakes of Malaya, 1954, pp. 107, 125.

Distira cyanocincta Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 294-296; Wall, Proc. Zool. Soc. London, 1903, pp. 96, 101; and Mem. Asiat. Soc. Bengal, vol. 1, 1906, p. 291; *ibid.*, vol. 2, 1909, p. 217, fig. and pl. 8 (*part.*).

Disteira cyanocincta Stejneger, Herpetology of Japan, 1907, p. 428; Taylor, Snakes of the Philippines, 1921, p. 245 (*part.*).

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* Presumably based on Russel's figure, p. 10, pl. 9, vol. 2 in A continuation of an account of Indian Serpents.

NOTE: A large number of nominal species described by various authors have been synonymized by Boulenger, Wall or M. Smith. The following species are so regarded: (See Malcolm Smith, [1926] for full synonymy). *Hydrophis striata* Schlegel, *chittul* Rafinesque, *subannulata* Gray, *aspera* Gray, *westermanni* Jan, *trachyceps* Theobald, *crassicollis* Anderson, *tuberculata* Anderson, *dayanus* Stoliczka, *tenuicollis* Peters, *taprobanica* Haly, *phipsoni* Murray, *D. macfarlani* Boulenger, *saravacensis* Boulenger, *longissima* Rosen. It seems likely that certain of these will eventually prove to be species or geographical subspecies.

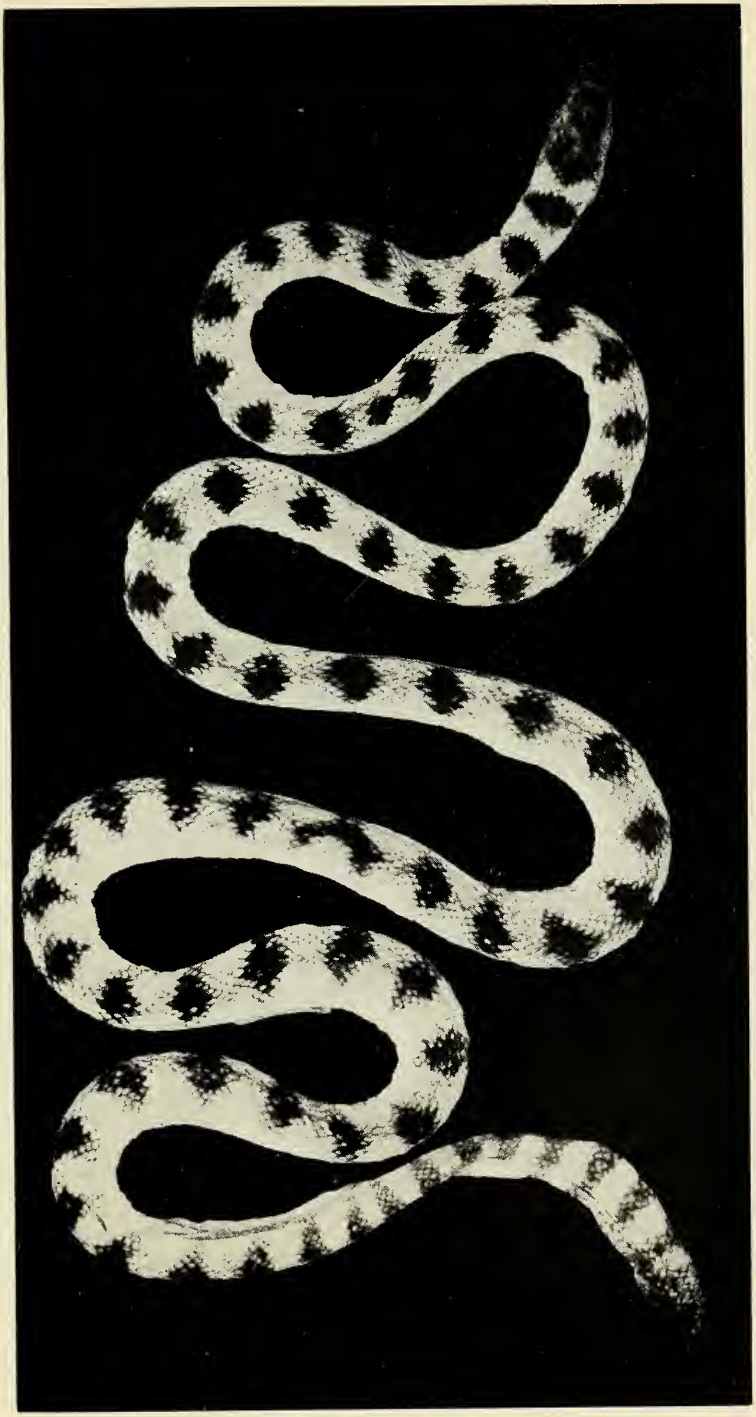

FIG. 111. *Hydrophis cyanocinctus* Daudin. No. 34612, Songkhla, Songkhla province, southern Thailand. Actual total length, 620 mm.; tail, 60 mm.

This species is very likely to be confused with *Hydrophis spiralis*. The latter species is not known from the seas bordering Thailand; however its presence on the west coast of the peninsula is probably, since it is known from Penang.

Diagnosis: A very large sea-snake reaching nearly two meters in length (1885 mm.; tail, 135 mm.). Five to seven teeth follow two large grooved fangs, after a short diastema; one preocular; two postoculars; usually two anterior temporals, variable in their relationships; second labial touching prefrontal; third, fourth, and fifth, or only fourth and fifth border orbit; three infralabials border first chinshields; yellowish with black rhombs on back, sometimes traceable around body, often becoming much narrower on venter (fading with age).

Description of species (from No. 696, Songkhla): Rostral about as high as wide, well visable above; snout sloping somewhat toward tip; nasals large, broadly in contact; the nostrils in posterior outer part of nasal scales; a suture from nostril to second labial may partly divide nasal scale; prefrontals touching second labial and preocular; frontal one and two-thirds times as long as wide, a little longer than its distance to rostral, shorter than parietals; latter scales more than twice as long as wide; one preocular, two postoculars, upper touching parietal, both touching upper temporal on right side (one only on left); supralabials eight, the third, fourth, and fifth bordering orbit (fifth on right side divided by a horizontal suture); infralabials (scales bordering lip), 9-10; first three infralabials border first chinshields, third separated from lip by a continuous series of small scales; second chinshields a little smaller than first pair, touching each other for a short distance, posteriorly separated by a pair of scales.

Scalerow-formula: 30 (29) (on neck), 39, 37; scales pointed posteriorly, longer than wide except anteriorly; scales keeled lightly; keels of dorsal scales divided into two short keels or tubercles; ventrals, 378, anteriorly with a width more than double adjoining scalerows; posteriorly smaller but usually larger than adjoining rows; ventrals usually lacking keels or tubercles; subcaudals, 45. Maxillary teeth, 2 + 7; four large elongated anal scales.

Color in life: Above yellowish olive on 24 dorsal rows; remainder of body scales yellow-cream; a series of 66 deep black rhombs on body reaching down to middle of side, and then continued around venter as a slightly darker shadow scarcely discernible but slightly

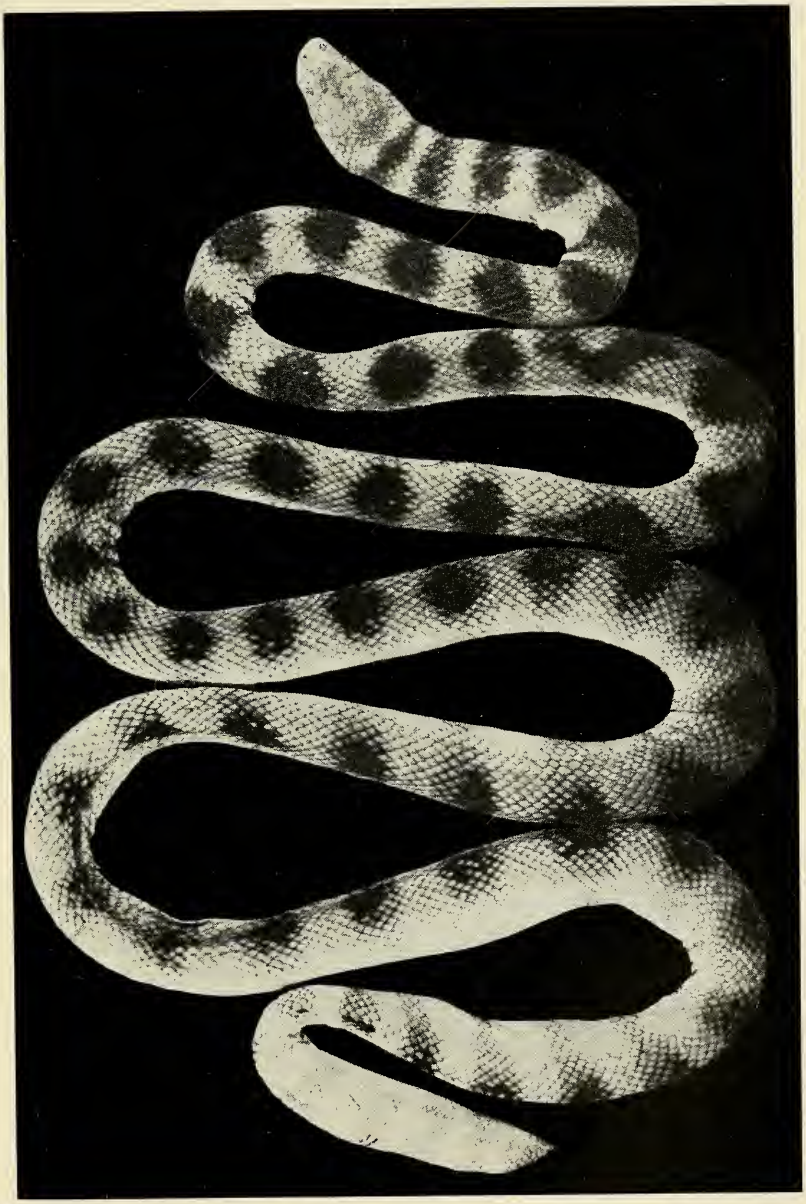

FIG. 112. *Hydrophis cyanocinctus* Daudin. No. 506 Songkhla, Songkhla province, southern Thailand. Actual total length, 1191 mm.; tail, 92 mm. Female with 62 bands on body and tail.

more evident posteriorly than anteriorly; seven bands on tail moderately distinct. Tail tip black. Head gray-olive with some yellowish olive on anterior head scales and labials; lower jaw with gray pigment.

Measurements in mm.: Total length, 1650; tail, 105; width of head, 20; length of head, 41.

Table of data on Thai specimens of *Hydrophis cyanocinctus*

NUMBER	696	698	506	289	578
Sex	♀	♀	♀	♀	♂
Total length (mm.)	1650	1479	1191	1045	972
Tail-length	105	110	82	69	95
Head-width	20	20	19	14	13
Head-length	40	36.5	25	24	24
Scalerows about neck	29	30	29	31	29
Scalerows about middle	39	39	38	37	39
Scalerows before vent	37	33	35	31	32
Ventrals	378	375	365	377	336
Subcaudals	45	41	38	44	46
Supralabials	8–8	7–7	8–8	8–9	8–8
Labials enter orbit	[3, 4, 5 [3, 4, 5	[3, 4, 5 [3, 4, 5	[3, 4 [3, 4	[3, 4, 5 [4, 5	[3, 4, 5 [3, 4, 5
Infralabials	10–10	10–10	10–10	8–9	9–9
Labials touch 1st chinshields	3–3	3–3	3–3	3–3	33
Black bands on body	66	72	55	59	54
Bands on tail	7	10	7	7	10

Variation: The table shows variation in a series of specimens from Songkhla. The ventral range (of all my specimens) is 336-404 both sexes; Malcolm Smith gives 290-390 as the known range for the species.

In No. 289, the light area on the head passes back above and behind the eye. The top of the head is gray from back of prefrontals to a point eight scales behind parietals. Anteriorly the spots are bluish with a small blackish center on the scales. Intervening areas with scales having hidden dark edges. The bands pass across venter but they are dim at a point on the sides.

Distribution: In Thailand the species is regarded as rather common along the coasts on the east side of the peninsula, especially those of the provinces of Songkhla and Pattani. It has been taken as far north as Bangkok and along the western coast of Trang.

Outside of Thailand it is known on the coast from the Persian Gulf to Japan and in the Indo-Australian Archipelago. The distribution, however, is not equal and in certain areas along the coasts it is quite unknown.

Hydrophis ornatus (Gray)

Aturia ornata Gray, Zoological Miscellany, 1842, p. 61 (type-locality unknown: M. Smith gives the type-locality as "Indian Ocean").

Two or possibly more subspecies of *ornatus* have been described, only a single one, the typical form is known from Thai waters.

Hydrophis ornatus ornatus (Gray)

Aturia ornata Gray, Zoological Miscellany, 1842, p. 61.

Distira ornata: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 290-291; Wall, Mem. Asiat. Soc. Bengal, vol. 2 (8), 1909, p. 232, figs. and pl. 9; Proc. Zool. Soc. London 1903, pp. 95, 101; *ibid.*, 1905, p. 517.

Hydrophis ornatus: Günther, The fauna of British India, 1864, pp. 376-377, pl. 25, fig. 5; de Rooij, The reptiles of the Indo-Australian Archipelago II, Ophidia 1917, p. 236; M. Smith, Monograph of the sea-snakes (Hydrophiidae) 1926, pp. 81-83, fig. 24; Bull. Raffles Mus., no. 3, 1930, p. 80; Tweedie, The snakes of Malaya, 1954, p. 108.

Hydrophis ornatus ornatus: M. Smith, The fauna of British India, Ceylon and Burma . . . vol. 3, Serpentes, 1943, pp. 460-461; Bourret, Les serpents marins de l'Indochine Francaise 1935, p. 42.

Hydrophis lamberti: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 340 (type-locality, mouth Meklong River, Bight of Bangkok); Journ. Federated Malay States, vol. 10, 1920, pl. fig. A.

Diagnosis: Head large, body stout; ten to thirteen maxillary teeth following poison-fangs; one preocular, two or three postoculars; two superimposed anterior temporals; usually no small cuneate scales on oral margin between third and fourth infralabials. Pale grayish or olivaceous to pure white above with broad dark bars or rhomboidal spots separated by narrow interspaces; below yellowish or whitish; head olivaceous.

Description of species: Maxillary teeth ten to thirteen behind poison-fangs; head large, usually about one half of greatest diameter of body; diameter of eye at least equal to its distance from mouth; frontal as long as its distance from rostral or end of snout; one preocular, two or three postoculars; supralabials seven or eight, second normally in contact with prefrontal, third and fourth border orbit; two superimposed anterior temporals; three infralabials bordering first chinshields; anterior pair of chinshields well developed, in contact, posterior pair poorly developed and separated by scales; usually no small cuneate scales on oral margin between third and fourth infralabials.

Scalerows on neck in males, 28 to 37; females 31 to 45 about body, 33 to 45 in males; females 39 to 55; posterior scales more or less hexagonal in shape, as broad or broader than long, subimbricate or juxtaposed with a central tubercle or short keel;

ventrals, 209 to 260 in males; 236 to 312 in females, distinct throughout, twice as broad as adjacent scales anteriorly, narrower posteriorly; preanals feebly enlarged.

Color in life: Pale grayish or olivaceous; sometimes nearly white with broad dark bars or rhomboidal spots, separated by narrow interspaces; below yellowish or whitish; head olivaceous.

Measurements in mm.: Total length, male 950; tail, 115; female, total length, 750; tail, 80.

Variation: The cross-bars vary in number from 30 to 59. Those known from Thailand waters have 30 to 38 bars. The bars may terminate bluntly halfway down the sides or taper gradually or be continued as faint lines around the body. Rarely they are confluent forming on dorsum a nearly uniformly colored band, except anteriorly.

Some specimens have large rounded spots on flanks alternating with the dorsal cross-bars.

Distribution: The species is rare in the Gulf of Thailand, three specimens appear to be the only ones known. I have not found it.

Hydrophis caerulescens (Shaw)

(Fig. 113)

Hydrus caerulescens Shaw, General zoology, vol. 3, 1802, p. 561 (type-locality, Indian Ocean).

Enhydris caerulescens: Merrem, Tentamen systematis amphibiorum, 1820, p. 140.

Hydrophis caerulescens: Gray, Zoological miscellany, 1842, p. 62; Catalogue of the snakes in the collection of the British Museum, 1849, p. 55; Günther, The reptiles of British India, 1864, p. 365, pl. 25, fig. C; Theobald, Journ. Linn. Soc., vol. 10, 1868, p. 66; Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 275-276; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 187; Sclater, List of snakes in the Indian Museum, 1891, p. 62; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, pp. 17-19, 46, 47; M. Smith, Journ. Nat. Hist. Soc. Siam. vol. 1, pt. 3, Mar., 1915, p. 214; M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 90-94, fig. 26; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 80-81; Bourret, Les serpents marins Indochine Française, 1935, p. 38; Les serpents de l'Indochine, 1936, p. 357; Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 463-464; Tweedie, The snakes of Malaya, 1954, p. 108; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1167-1168, fig. 35.

Disteira caerulescens: Wall, Mem. Asiat. Soc. Bengal, vol. 2, no. 8, 1909, p. 231.

Polyodontophis caerulescens: Prater, Journ. Bombay Nat. Hist. Soc., vol. 30, 1924, p. 174.

Polyodontognathus caerulescens: Wall, Ophidia Taprobanica, or the snakes of Ceylon, 1921, pp. 375-380, fig. 71.

Hydrophis frontalis Jan, Elenco sist, ofid., 1863, p. 110 (type-locality, Océan des Grandes Indies); Jan and Sordelli, Iconographie générale des ophidiens,

livr. 39, 1872, fig. 2; Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 276; de Rooij, Reptiles of the Indo-Australian Arch., vol. 2, Ophidia, 1917, p. 227.

Hydrophis hybrida Schlegel, Abbild. neuer. Amphib., 1844, p. 115, col. pl. 37; Jan and Sordelli, Iconographie générale des ophidiens, livr. 41, 1872, pl. 5; Boulenger, Catalogue of the snakes of the British Museum, 2nd Ed., vol. 3, 1896, p. 274; de Rooij, Reptiles of the Indo-Australian Archipelago, 1917, p. 233.

Hydrophis polyodontus Jan and Sordelli, Iconographie générale des ophidiens, livr. 41, 1872, pl. 1 (type-locality unknown); Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 274; de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 233.

Hydrophis caerulescens thai M. Smith, Journ. Federated Malay States Mus., vol. 10, 1920, p. 18 (type-locality, Hua Hin, on Gulf of Siam).

Diagnosis: Medium length sea-snake with a moderately small head, body not especially slender anteriorly; a series of from 13-18 maxillary teeth of same size following poison-fangs, after a diastema; third and fourth supralabials border orbit; small scales at oral margin following third and fourth infralabials; scalerows on neck, 31 to 43; on body, 38 to 54, strongly keeled; ventrals somewhat enlarged, distinct. Head black with or without a curved yellow mark.

This sea-snake has the largest number of maxillary teeth in the recognized species of *Hydrophis*.

Description of species (from No. 327, Songkhla): Rostral wider than high, well visible from above; nasals large, broadly in contact with each other, narrowed posteriorly; nostril dorsal, with a suture running from nostril to second labial partly dividing scale; prefrontals somewhat angular posteriorly, smaller than frontal; frontal wider than supraoculars, as long as its distance from rostral, shorter than parietals; one preocular, one (two) postoculars, latter touching three (or two) anterior temporals and parietal. Supralabials, eight, second touching prefrontals, third and fourth bordering orbit, last four small; three anterior temporals, (on right side two), lowermost fused with lower postocular, touching eye border; infralabials, nine, first pair segmented transversely, leaving a pair of scales between them and first chinshields; three infralabials touching first chinshields; a small cuneate scale between third and fourth infralabials on oral border; last five infralabials small. All head scales with numerous fine tubercles.

Scalerows: At neck, 33; about widest part of body, 41; before vent, 32; scales keeled, the keels elevated posteriorly often ending in a short spine, longer dorsally, shorter and bituberculate and more spinous ventrally. Ventrals distinct, 322; subcaudals, 50.

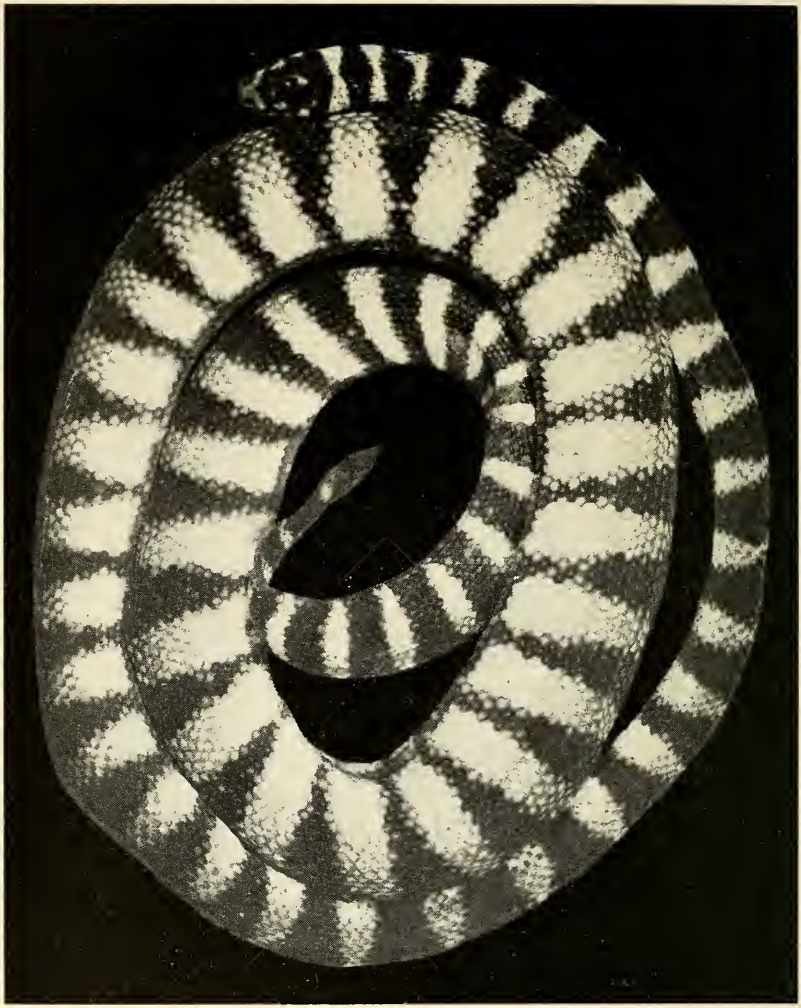

FIG. 113. *Hydrophis caerulescens var.* No. 34624, Sea of Singgora, near Phatthalung, Phatthalung province, southern Thailand. Actual total length, 901 mm.; tail, 119 mm. (from fresh water).

Color in life: Head black without trace of lighter markings; body somewhat grayish dorsally; remainder yellowish to dirty white; 50 bands on body, anteriorly as wide above as below; posteriorly wider dorsally and narrowing laterally; seven bands on tail.

Measurements in mm.: Total length, 712; tail, 78; width of head, 9; length of head, 16.

Variation: The number of small maxillary teeth varies between 13 and 18; the body has a diameter in the adult varying from two

to three times the diameter of neck. The diameter of the eye is equal to or a little greater than its distance from the mouth. The temporal scales are especially variable seemingly caused in part by splitting of the fifth supralabial and occasional fusion of the sixth or seventh with a temporal.

The scales at times seem to be subimbricate and frequently the posterior scales are truncate and juxtaposed.

The number of bands varies from about 40 to 54. In very old specimens the spots are so indistinct as to be scarcely recognizable. Maximum length is probably less than 850 mm.

Distribution: In the Gulf of Siam the species is common along the Thai coasts, and most probably also occurs on the west coast (Bay of Bengal). Elsewhere the species is widespread.

Malcolm Smith (1920) named this form found in Siamese waters, *H. caerulescens thai,* characterized by having an average of 292 ventrals, the neck scales, 31-37; the body scales, 38-49; the parietals usually in contact with the postocular. In his later works Smith (1926-1943) synonymized the form, presumably the overlap of the scale counts left but little to differentiate the form in the Gulf of Siam from the typical form occurring in the Straits of Malacca and the shores of India and Burma. I have followed him in this treatment of the name.

The specimen figured, from the Sea of Singgora, differs in having more bands and is larger than usual. (901 mm.).

Hydrophis torquatus Günther

Hydrophis torquatus Günther, Reptiles of British India 1864, p. 369, pl. 25 (type-locality, Penang).

In his work on the sea-snakes, Malcolm Smith recognized three subspecies of *torquatus* concerning which he states, —"Three forms can be distinguished, varying slightly from one another in scalation and coloration."

Two of these, *t. aagaardi* and *t. diadema,* occur on the west coast of the Malay Peninsula in the Gulf of Siam. While the typical form occurs on the Bay of Bengal side of Malaya only a little below the Thai border, it almost certainly occurs on the west coast of peninsular Thailand.

These forms may be differentiated by the following key:

KEY TO THAI SUBSPECIES OF *Hydrophis torquatus*

1. 33-37 scalerows on neck; 43 to 49 on body; ventrals 242-306 (average 278). Head in adult pale gray with a suffusion of yellow above. Bay of Bengal, straights of Malacca ..... *torquatus torquatus*

2. 31-37 scalerows on neck; 39-47 on body. Ventrals 276-325 average 297. Head in adult blackish to dark olive with yellow marks across snout and along the sides above and behind eye..... *H. t. aagaardi*
3. 29-35 scalerows on neck; 35 to 42 on body; ventrals 271-343 (average 301). Head markings the same..... *H. t. diadema*

Hydrophis torquatus diadema Günther

Hydrophis diadema Günther, Reptiles of British India, 1864, p. 373, pl. 25, fig. 5 (type-locality unknown); Peters, Monatsb. Akad. Wiss. Berlin, 1872, p. 895; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 188; de Rooij, The reptiles of the Indo-Australian Archipelago, 1917, pp. 229-230.

Hydrophis obscurus: Flower, Proc. Zool. Soc. London, 1899, p. 687 (not of Daudin).

Hydrophis tuberculatus: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, 1915, pp. 214, 247 (not of Anderson).

Hydrophis siamensis: M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, pp. 341-342 (type-locality, mouth of the "Chantaburi" River, Gulf of Siam); Journ. Bombay Nat. Hist. Soc. vol. 26, 1919, p. 682.

Hydrophis torquatus siamensis: M. Smith, Journ. Federated Malay States Mus., vol. 1, 1920, pp. 15-17, 43-44.

Hydrophis cyanocinctus: Wall, Journ. Bombay Nat. Hist. Soc., vol. 25, 1918, p. 754, fig. (not of Daudin).

Hydrophis torquatus diadema: M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 79-81; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes 1943, p. 460; Bourret, Les serpents marins de l'Indochine Française, 1935, p. 39; Les serpents de l'Indochine 1936, p. 359.

Diagnosis: A species with a medium-large head; elongate body moderately slender anteriorly, compressed posteriorly. Head black or dark olive with yellow markings on snout and along sides of dorsal part of head; variable temporal formula; neck scalerows, 29-35, body rows, 35-42(51); ventrals, 271-343, distinct throughout; most specimens completely banded.

Description of species (from M. Smith 1926): This form differs from the typical form and from *aagaardi* in having fewer scalerows on neck (29 to 35, [usually 31-33]); 35 to 42 (usually 37 to 39 on the body); ventrals 271 to 343 (average for 84 specimens 301).

Color: Head black, the yellow markings usually more diffuse, in some specimens in excess of the ground-color. Most specimens are completely banded. The character of temporals is unstable, usually one, there may be two to four on one or both sides.

Measurements in mm.: Largest male, total length, 895; tail, 115; largest female, 1045, tail, 105.

Distribution: "From Meklong on the west side of the Gulf of Siam to Koh Chang (island) on the east." It is particularly abundant at the mouths of the Meklong and Chanthaburi rivers.

Hydrophis torquatus aagaardi Günther

(Fig. 114)

Hydrophis torquatus aagaardi M. Smith, Journ. Federated Malay States Mus., vol. 10, pt. 1, July 1920, pp. 13, 14-15 (type-locality, coast of "Bangnara, Pattani" [= Narathiwat, Narathiwat] Gulf of Siam). I have retained this form as a legitimate subspecies despite the fact that specimens from Songkhla at the mouth of the Sea of Singgora, vary somewhat from specimens from farther south at Narathiwat, the type-locality.)

Diagnosis: (see key).

Description of species (from No. 340, Songkhla): Head moderately large, twice as long as wide, neck and anterior part of body not especially slender. Rostral approximately one-fourth wider than high, well visible above; nasals large, mesially in contact, extending noticeably behind level of nostrils, partially divided by a suture from nostril to second labial; prefrontals touching second labial; frontal pointed behind, its length equal to its distance from rostral, shorter than parietals; one preocular, one postocular; two anterior temporals, upper very much the larger; this followed by a large secondary temporal on one side, (one and one on the other); supralabials eight, second largest, third and fourth bordering orbit, last four small; supraoculars only a little narrower than frontal; infralabials ten, first four large, three bordering first pair of chinshields which are equal or nearly equal to second pair; two small cuneate scales on oral border between second and fourth infralabials; eight rows of small scales between chinshields and first ventrals.

Scalerows about neck, 39; about widest part of body, 40; before vent, 32; scales keeled or with two tubercles, usually a larger one followed by a smaller one; scales on neck imbricate, pointed posteriorly, bluntly truncate, subimbricate or juxtaposed. Ventrals, 312; subcaudals, 59; lateral anal scales much enlarged, separated by a somewhat smaller median pair, anteriorly bearing two larger tubercles followed by a pair of small tubercles. Ventrals distinct throughout; toward posterior part of body there are two or three short groups of divided ventrals. Hemipenes black.

Color: Body somewhat yellowish with a series of 52 dark-olive bands on body and ten on tail; bars anteriorly completely surrounding body, posteriorly they cannot be traced across venter except those near vent; dorsally separated by dark olive only a little less dark than bands, growing yellowish and (posteriorly) wider on venter; many scales have blackish centers, while lower on sides the yellowish scales are somewhat darker on edges. Head dark;

FIG. 114. *Hydrophis torquatus aagaardi* M. Smith. No. 322 ♀, Songkhla, Songkhla province, southern Thailand. Actual total length, 848 mm.; tail, 107 mm.

diffuse yellowish bars surrounding tail, distinctly wider than interspaces. Markings on snout and sides of head; two oval dark-centered spots on each side of nape; infralabials and chinshields gray.

Measurements in mm.: Total length, 1053; tail, 135; greatest depth of tail, 17; depth of body, 21; width of head, 13; length of head, 26; depth of neck, 13.

Variation: The lower anterior temporal is very much smaller than the upper which lies somewhat posterior to the first. The large secondary temporal may be segmented by a vertical suture or it may break into several pieces. Occasionally there is a second postocular, presumably formed by the segmentation of the posterior portion of the fourth supralabial.

The maxillary teeth are found to vary between 9-11, ten appearing six times in eleven specimens.

Measurements in mm., and data on *Hydrophis torquatus aagaardii*

NUMBER	374	380	340	341	342	321	322	373	296	480	557
Sex	♂	♀	♂	♀	♀	♀	♀	.....	♀	.....	♂
Total length	975	827	1053	802	927	827	848	681	637	605	805
Tail	126	95	135	97	105	94	107	80	68	78	100
Neck, scalerows	40	36	39	37	37	36	40	37	36	37	39
Body, scalerows	41	41	40	41	39	42	43	39	41	42	41
Supralabials	8–8	7–7	8–8	8–7	7–7	7–7	8–8	8–8	7–8	7–7	7–7
Infralabials	10–10	10–10	11–11	10–11	10–10	10–10	9–9	9–9	10–10	9–9	11–10
Temporals	2+2	2+1	2+2	2+2	1+2	2+2	2+2	2+2	2+2	2+2	2+2
Ventrals	329	306	312	306	305	316	286	313	319	286	293
Subcaudals	60	52	59	47	54	53	52	50	51	54	52
Body-bands	56	52	52	52	54	54	50	49	44	54	52
Tail-bands	10	6+	10	10	9	10	9	9	7	10	10
Maxillary teeth	9	10	11	11	10	10	9	9	10	10	10

The bands on the body vary from (44) 49-56, 52 being the most frequent number; on the tail ten is the most frequent number of bands; however when smaller numbers are present the terminal black portion is proportionally wider.

Remarks: The specimens from Songkhla fail to fit the averages given by M. Smith. Unfortunately the sample consists of only ten specimens, while Smith's own series was 44. He states: "All the specimens were taken in deep, clear sea-water, being caught in trawling nets, some as far as 20 miles from the coast." My series were taken largely in the sea of Singgora or at varying distances from the mouth.

The average number of ventrals in *aagaardi* is given by Smith as 297, while my Songkhla series has an average of 306 (the total variation being 286 to 339); the scales on the neck in Songkhla specimens vary between 36 and 40, the average being 37.7; scales around body vary between 39 and 42; average 41. These may be compared with *aagaardi* with the scales on neck usually being 33 to 35, and on body 42 to 45.

It is entirely possible that a larger sample from Songkhla would show a greater correlation with the type series.

While there is a strong possibility that the typical form, *torquatus torquatus* occurs on the western coast of peninsular Thailand, the type-locality being at Penang Island, I have not included a description.

Hydrophis klossi Boulenger

(Figs. 115, 115a, 116)

Hydrophis klossi Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 190 (type-locality, Thuala, Selangor, Malaya); Smith, Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, p. 787; Journ. Federated Malay States Mus., vol. 10, 1920, p. 19, pl. figs. B; Bull. Raffles Mus., no. 3, 1930, p. 78 ("Gulf of Siam as far south as Pattani"); Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 68-70, fig. 21 (Bangkok, Bay of Pattani, Songkhla); Tweedie, The snakes of Malaya, 1954, pp. 106-107.

Hydrophis nigrocinctus: Laidlaw, Proc. Zool. Soc. London, 1901, p. 579 (*part.*) (not of Daudin); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 187.

Diagnosis: A medium-sized sea-snake (1300 mm.) with a small head and anterior part of body long and slender, enlarged and slightly compressed posteriorly; snout somewhat projecting; scales distinctly imbricate throughout neck, body and tail; ventrals distinct, not divided; body with 50 to 75 (usually 60 to 70) black bands; intervening color gray, green, or ivory-white. Head black in young, becoming lighter in older specimens, often with a narrow semicircular mark on back of head.

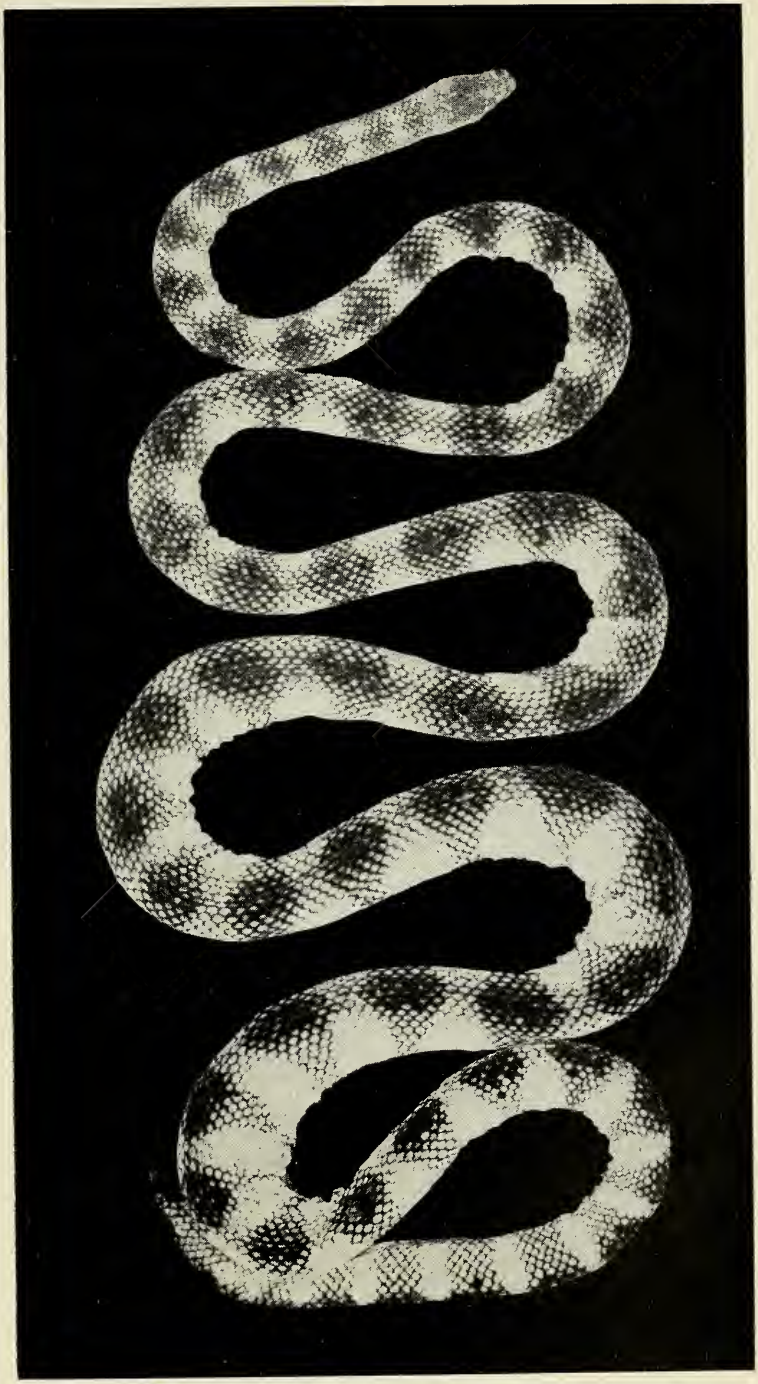

FIG. 115. *Hydrophis klossi* Boulenger. No. 35570 Songkhla, Thailand. Actual total length, 817 mm.

Description of species (from No. 504, Songkhla, peninsular Thailand): Head very small, snout projecting; neck and anterior part of body slender, head not distinct from body; posterior part of body two and one-half to three times diameter of neck; five or six maxillary teeth behind poison-fangs. Rostral as high as wide, angular posteriorly, narrowly visible from above; nasals elongate, broadly in contact with each other, nostril in outer posterior portion, with a suture running from nostril to second supralabial; (the rim of nostril broken on left side abnormally); prefrontals relatively very large, much more than half size of nasals, and four fifths of area of frontal; frontal slightly longer than wide, its length equal to its distance from middle of nasals, much shorter than parietals, only slightly wider than large supraoculars; one preocular and one postocular; one very large anterior temporal followed by (left side) one large elongate temporal, on (right side) second divided vertically in two; five supralabials, second largest, touching prefrontal, third and fourth border orbit; fifth touching postocular; five large and two small infralabials, first three touching first chinshields; second pair of chinshields well developed, separated by a scale touching two labials; first pair of infralabials nearly as long as both pairs of chinshields; nine scalerows between second chinshields and first widened ventral.

Scalerows: 23 (24) scales about neck; 33 at widest part of body, 32 before vent; ventrals only about a half larger than adjoining scales and bearing two distinct keels; other scales with one keel about half length of scale, keels absent or dim on neck; scales on sides above anal region smooth; caudal scales keeled. Ventrals, 391; subcaudals, 57; outer pair of anals moderately large, median pair about same size with two small intercalated scales.

Color in life: Dorsally gray, edges of scales darker on middle fifteen dorsal rows; below on sides and venter, yellowish to ivory-white. Head dark above, lighter on snout and anterior nasals. A whitish temporal spot and a semicircular row of white dots on occiput; chin and underside of head dirty yellowish clouded with darker; a black bar on nape, convex anteriorly. Neck and anterior part of body black with yellowish bars reaching ventral surface narrower than black bars; from here posteriorly, body with black and light bands. Total yellow bands, 65, anteriorly incomplete, and an equal number of bluish bands wider dorsally, narrower ventrally.

Measurements in mm.: Total length, 785; tail, 74; width of head, 6.8; length of head, 12.6.

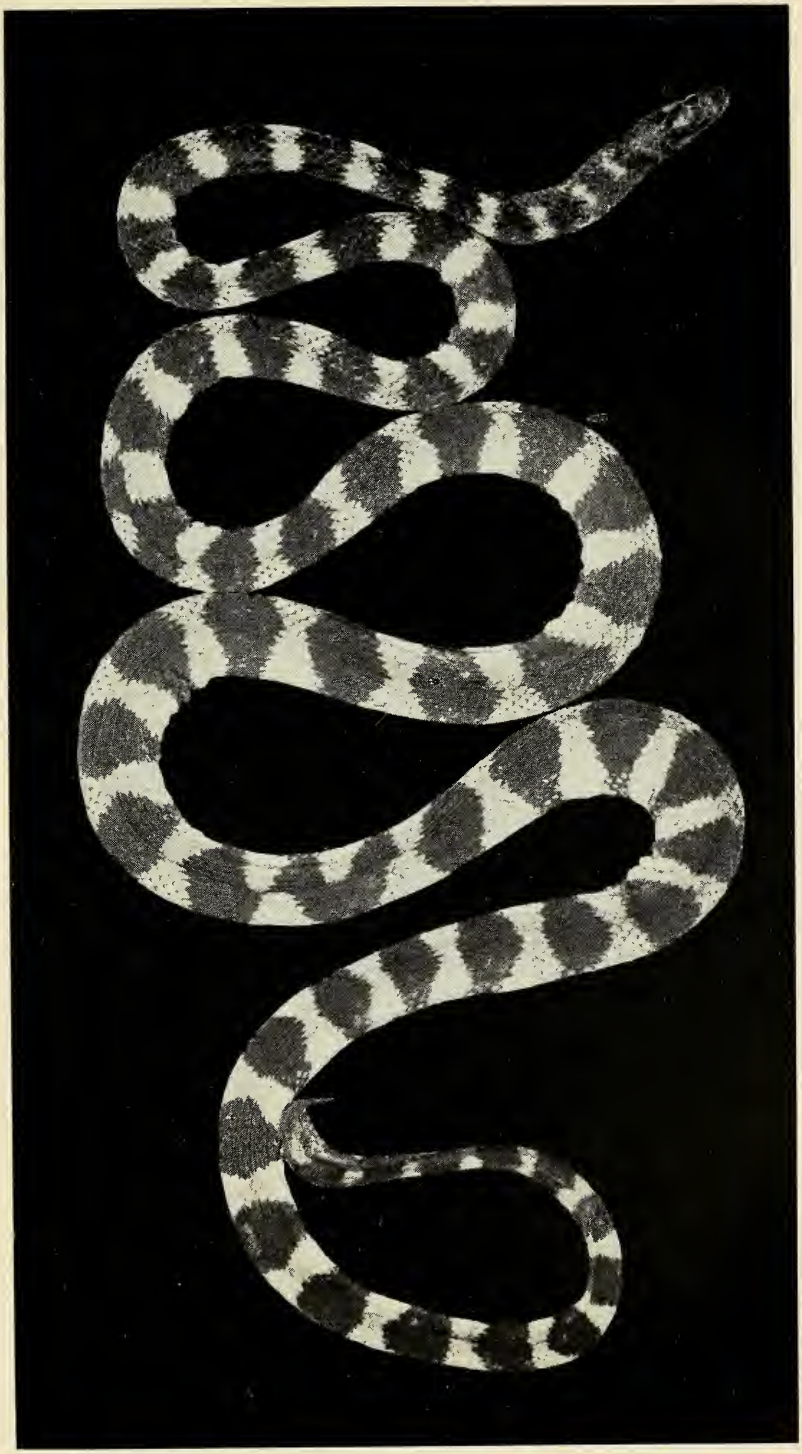

FIG. 115a. *Hydrophis klossi* Boulenger. No. 34628, young, Songkhla, Songkhla province, southern Thailand. Actual total length, 690 mm.; tail, 64 mm.

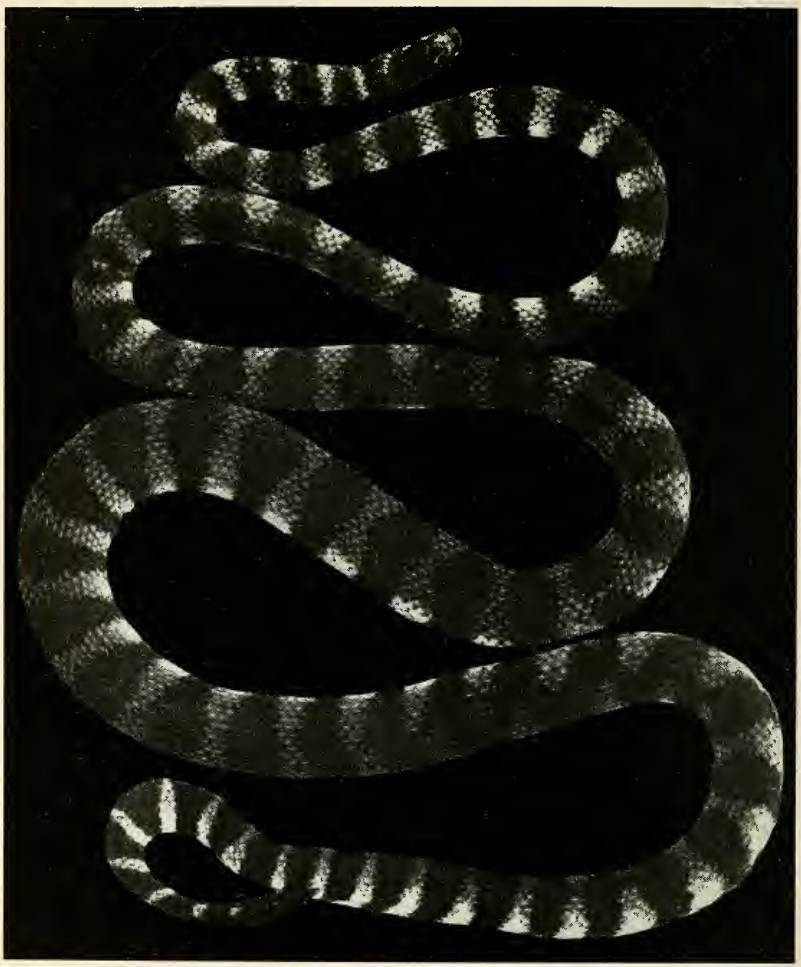

FIG. 116. *Hydrophis klossi* Boulenger. No. 1720, Songkhla, Songkhla province. Actual total length, 770 mm.; tail, 71 mm.

Variation: I am referring a young specimen (No. 532 Songkhla) to this species. It differs as follows: Head and body are black for more than one third of its length. About 20 mm. back from head a series of very small paired light spots appear on the sides and continue, later joining on the middorsal line, forming 54 pairs or bars. At number 21 the white color reaches to ventrals which are black, the black bars completely surrounding body; the following 14 black bands fail by several scalerows from reaching the

ventrals; the last four black bands however, do encircle the body. There are four pairs of yellowish spots on the tail. There are 23 scalerows about neck, 33 at widest part of body. The ventrals are 397, subcaudals, 51. The outer anal scales are much enlarged and separated by four small scales.

The known variation in ventral scales in specimens from Thailand is from 360 to 430 the average numbering approximately 390. There is seemingly no significant sexual difference where counts of the sexes are averaged separately.

There are rarely six labials present, the sixth being very small. The number of bands vary from 50 to 75. The light mark on occiput may be absent.

Remarks: The species is known along the east coast of peninsular Thailand as far south as Pattani. It is known also on the west coast of northern Malaya (Perak and Selangor).

Both males and females reach a length of more than one meter. The largest specimen listed by M. Smith, 1943, is a female with a total length of 1300 mm., the tail 100 mm.

This snake when young looks much like *Microcephalophis gracilis.* The characters that may be used to differentiate them are the imbricating scales of *H. klossi,* and the divided ventrals, each part with three keels, of *M. gracilis.*

Hydrophis fasciatus (Schneider)

Hydrus fasciatus Schneider, Historiae amphibiorum naturalis et literariae, fasc. primus . . . 1799, pp. 240-241 (type-locality, East Indies); M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 94-99.

Dr. Malcolm Smith recognizes two subspecies of *fasciatus,* those west of the Malay peninsula being regarded as the typical *f. fasciatus,* while to those east of the peninsula the name *f. atriceps* Günther is applied.

These two forms may be differentiated by the following key:

KEY TO SUBSPECIES OF *Hydrophis fasciatus*

1. About neck 27 to 33 scalerows; about body, 47 to 58; ventrals 414 to 514 (average 460)..... *fasciatus fasciatus*
2. About neck 25 to 31 (usually 27 to 29); about body, 39 to 49 (usually 43 to 45); ventrals 323 to 453 (average 366 or less)..... *fasciatus atriceps*

Only *atriceps* has been taken in Thai waters. However little collecting has been done on the coast of the Bay of Bengal, and *f. fasciatus* may be found there.

Hydrophis fasciatus atriceps Günther

(Fig. 117)

Hydrophis atriceps Günther, Reptiles of British India, 1864, p. 371, pl. 25, fig. 1 (type-locality, "Siam").

Disteira fasciata: Boettger, Katalog der Reptilien-Sammlung im Museum der Senckenbergischen Naturforschenden Gesellschaft, Teil II Schlangen, 198, p. 113 (Manila).

Hydrophis fasciatus: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 281 (*part.*); de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 230; Roux, Abh. Senckenberg. Nat. Ges., Frankfurt, vol. 33, 1910, p. 221.

Hydrophis alcocki Wall, Mem. Asiat. Soc. Bengal, vol. 1, 1906, p. 288, fig. (type-locality, Puri, Orissa, India).

Disteira cincinnatii Van Denburgh and Thompson, Proc. California Acad. Sci., vol. 3, 1908, p. 41, pl. (type-locality, Philippines); Taylor, The snakes of the Philippine Islands, 1922, p. 239, fig.

Hydrophis fasciatus atriceps: M. Smith, Journ. Federated States Mus., vol. 10, 1920, p. 25; Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 97-99, fig. 27; Bull. Raffles Mus., no. 3, 1930, p. 82; Tweedie, Snakes of Malaya, 1954, p. 110.

Diagnosis: Snakes with small heads; bodies slender anteriorly, larger and compressed posteriorly; five to six maxillary teeth behind poison-fangs; head black, chin black followed by a black stripe along neck and anterior part of body, joining first eight to 20 black bars; body cream, banded in black; anterior bands wider than interspaces; one anterior temporal followed by one scale or latter may be divided vertically.

Description of species (from No. 584, Songkhla): Head very small, anterior part of body slender but gradually becoming larger and compressed; rostral distinctly wider than high, well visible above; nasals large, broadly in contact, nostril pierced very close to outer posterior part of scale with a very short suture to second labial from nostril; prefrontals wider than long, touching second labial below level of nostril; frontal elongate, its length equal to its distance from rostral, shorter than parietals; three scales between temporals behind parietals; one preocular; one postocular touching fifth labial, anterior temporal, and parietal; anterior temporal large, followed by a secondary temporal equally as large or a little smaller; supralabials six, second largest, last smallest, third and fourth border orbit; seven or eight infralabials, first three bordering first chinshield; fourth largest; a small intercalated cuneate scale between third and fourth infralabials on oral border; chinshields well developed, second pair longest, in contact, as is the first pair.

Scalerows: 28 on neck, 40 widest part of body, 36 before vent; scales imbricate anteriorly, subimbricate, to nearly juxtaposed pos-

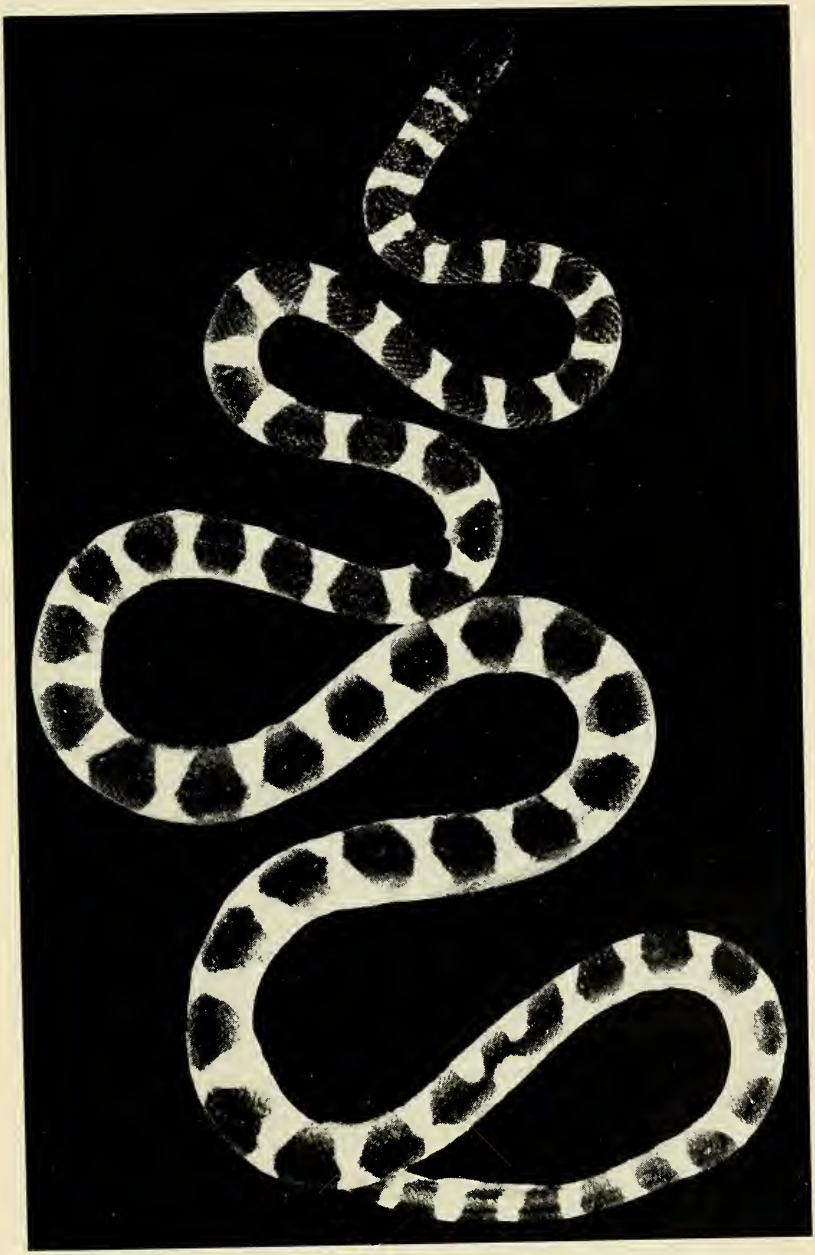

FIG. 117. *Hydrophis fasciatus atriceps* M. Smith. No. 1921, Songkhla, Songkhla province, southern Thailand. Somewhat enlarged.

teriorly; many scales truncate posteriorly; most scales with a median tubercle. Ventrals 409, subcaudals 53, anal scales much enlarged, separated by a pair of smaller scales; each ventral with two small tubercles.

Color in life: Head black with a tiny yellow spot behind eye; on chin and for a short distance on anterior part of body, a black stripe narrowing posteriorly; body black-olive and greenish white to cream, the colors forming bands; 56 black bands narrowing laterally becoming obsolete on venter, separated on mid-line by narrow lighter bars, first eight or ten joining ventral stripe; nine bars on tail.

Measurements in mm.: Total length, 843; tail, 80; width of head, 6; length of head, 11.8.

Variation: Malcolm Smith's series of *atriceps* from Thailand were taken largely from coasts bordering the northern part of the Gulf of Siam. They vary considerably from a southern series which I took at Songkhla containing about an equal number of males and females.

The ventral counts for the typical *fasciatus* is given as 414-514 with an average of 460; for *atriceps*, 323-453, an average of about 366. Thus there is a presumed average difference of 94 ventrals. My series of 17 specimens from Songkhla show a maximum variation in ventrals from 380 to 441, or 61 scales. This is surprisingly different from that reported for the specimens from the northern coast—a difference of 40 scales.

The known range of scalerows on neck is from 25 to 31, for the body, 39 to 49. In the Songkhla series, the range varies from 27 to 31; and 41 to 48. The bands on the body are known to vary between 50 and 75; while in the Songkhla series they are 52 to 67, the average being 59. The bands on the tail vary between 6 and 11, the usual number for males being 9, for females 7. The anterior temporal frequently fuses with the last labial thus bordering on the mouth, while the second temporal is occasionally divided by a vertical suture.

The form reaches a length of one meter.

Distribution: The subspecies is probably present everywhere along the coastline of Thailand bordering on the Gulf of Siam. Elsewhere the species occurs in the Philippines, the coast of Cochin China, Sumatra, Java, New Guinea and perhaps Australia. Occasional specimens have been reported from Rangoon and Orissa (*fide.* Malcolm Smith).

Hydrophis brookei Günther

Hydrophis brookei Günther, Proc. Zool. Soc. London, 1872, p. 597 (type-locality, Sarawak, Borneo); Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 282-283; de Rooij, Reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, p. 230; M. Smith, Monograph of the sea-snakes (Hydrophiidae), 1926, pp. 99-101; Bourret, Les serpents marins de l'Indochine Française, 1935, p. 48; Les serpents de l'Indochine, 1936, p. 367; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 82-83; Tweedie, The snakes of Malaya, 1954, pp. 109-110.

Disteira fasciata (*part.*): Wall, Mem. Asiat. Soc. Bengal, vol. 2, no. 8, 1909, p. 205, fig.

Hydrophis consobrinus M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 341 (type-locality, Gulf of Siam, mouth of Bangpakong River); Journ. Federated Malay States Mus., vol. 10, 1920, pp. 20-22, 49-51, pl., fig. C.

Diagnosis: A sea serpent reaching somewhat more than one meter in length; head very small, as is the neck and anterior part of body; body much compressed posteriorly, its greatest diameter two and a half to three times diameter of neck. Posterior scales subimbricate and hexagonal in shape. Grayish above, yellowish white below; 60 to 80 blackish bands encircle body and tail, anteriorly of nearly even width above and below, twice as broad as interspaces and narrowing on sides posteriorly; head black with a yellow band across snout and along sides of head.

Description of species (from No. 377, Songkhla): Head very small, anterior part of body very slender; rostral wider than high, slightly visible from above; nasals subrectangular, broadly in contact; prefrontals somewhat diagonal much wider than long, broadly in contact with second supralabial; frontal much wider than supraoculars, about as long as its distance from rostral, shorter than parietals; parietals notched laterally by a suture (anomalous?); one preocular; one postocular touching parietal, temporal and two supralabials; a large anterior temporal, its lower point scarcely separated from labial border; second temporal divided by a vertical suture; four scales behind parietals between the two posterior temporals. Supralabials six, third and fourth border orbit; diameter of eye a little greater than its distance from mouth; infralabials seven or eight, first four large, others small; three scales border first pair of chinshields which are subquadrangular, about as wide as long, in contact; second pair of chinshields longer than first, pointed behind, in contact with each other anteriorly; five scalerows between these and first ventral; a small cuneate scale on labial border between third and fourth infralabials.

Scalerows: 32 about neck, imbricate, keeled, pointed behind; 38 at widest part of body; 33 before vent; posterior scalerows sub-

imbricate or almost juxtaposed, scales truncate posteriorly; dorsally, keels ending posteriorly in a small spine; laterally and ventrally with a tubercle, which is sometimes spinous. Ventrals, 372 distinct, double or nearly double width of adjoining scales, bituberculate or with two or three accessory posterior smaller tubercles; outer preanals large, separated by a smaller median pair; subcaudals, 57.

Color in life: Above generally slate-gray, with yellowish white on venter; head dark with lighter marks on head above eye; a series of 64 bars on body fairly distinct anteriorly, surrounding body, first 24 about as wide above as on venter, a little wider than intervening spaces; posteriorly narrowed laterally and not passing across venter except four preceding vent; ten bands on tail; a broken median ventral blackish line throughout latter half of body.

Measurements in mm.: Total length, 965; tail, 96; width of head, 6; length of head, 12.5; greatest depth of body 26; diameter of neck, 6.

Variation: Variation in coloration between the young and adults is marked. In young specimens the head is dark with yellowish marks on nasals and prefrontals, and two indefinite yellowish marks along the sides of head above eye, and on temporals. In specimens measuring 600 mm. or more the bands are very distinct but those in the latter half of the body do not cross the venter. Many lack the blackish ventral line. The head, in a specimen of this length is 5 mm. wide and 10.5 mm. in length.

Variation in the number of scalerows is between 25 and 31 on neck, 37 to 45 on body. Thai specimens usually have 25 to 28 on neck; 37 to 42 on body; the variation in ventrals is 358 to 414, the average being about 375.

Distribution: The species is common in the Gulf of Siam, especially so at Songkhla, where a series of 42 were taken. It is known also on the western side of Thailand on the coast of Trang province. Elsewhere it is known on the coasts of Cochin China and northern Borneo and Java.

It is difficult sometimes to separate this species from *Hydrophis fasciatus fasciatus* and *fasciatus atriceps,* the latter occurring with *brookei* in the Gulf of Siam.

[*Hydrophis mamillaris*] Daudin

(Fig. 118)

Hydrophis mamillaris Daudin, Histoire naturelle générale et particulière des reptiles, vol. 7, 1803, pp. 340-342; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, Dec.,

1943, pp. 462-463; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar., 1958, pp. 1164-1166, fig. 34 (Bangphu, Bangkok).

Diagnosis: Eight to ten maxillary teeth behind the enlarged grooved fangs; head small, body slender anteriorly, seven supralabials, a small cuneate scale on oval margin; 25 to 29 scalerows around neck; 35 to 43 around body; ventrals 302-390, bicarinate.

Description of species (KUMNH No. 33517): Rostral well visible above; nasals large, elongate, in contact mesially; nostrils dorsal; prefrontals much wider than long, in contact laterally with the large second labial; frontal about as long as its distance from rostral; shorter than parietals; preocular 1 (2); one postocular; seven supralabials, the fourth enters orbit, last three small; infralabials 10-10, three touching first chinshield the second and third separated from lip by two (three) small cuneate scales; posterior infralabials small; a single large anterior temporal followed by a still larger temporal scale; latter followed by a third large temporal bordering parietal; four small postparietals.

Scale-formula: 36 (occiput), 33, 39, 32; ventrals about 325, not double width of adjoining scales. Two much enlarged preanals separated by two and a half pairs of scales, the last pair mesial and extending somewhat behind the enlarged scales.

Head and neck about one third greatest diameter of body. Ten maxillary teeth following the larger grooved fangs.

Color: Head black with a yellowish streak on each side behind eye; body blackish with 55 dark bands on body, and seven on flattened tail, wider dorsally narrowing posteriorly on sides, except for first eight, while bands encircle body or fail to meet below by a very narrow margin. Dorsal and upper lateral scales of light bands may have considerable pigment forming indefinite darker spots on some scales; most dorsal scales with keels or tubercles, especially posteriorly the keels are tuberculate; scales of median dorsal row often with two tubercles, one behind the other; while ventrals may have two lateral tubercles.

Remarks: Taylor and Elbel (*loc. cit.*) referred this specimen to this species in 1958 with considerable hesitation and I am uncertain still as to whether it is a somewhat aberrant *mamillaris*, or an aberrant specimen of some other form or perhaps a totally separate form.

Superficially it resembles *brookei* but the teeth are twice the number known in that form. The temporal scales resemble those of *brookei* but there are more supralabials, 7 instead of 5 or 6; there

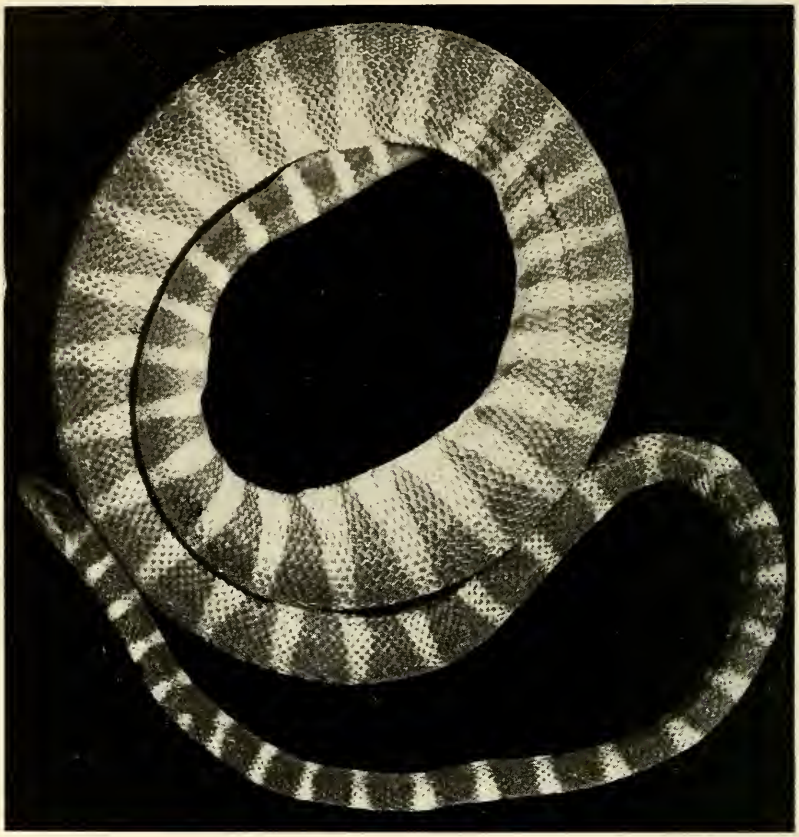

FIG. 118. *Hydrophis mamillaris* (Daudin). KUMNH No. 33517, Bangphu, Bangkok (about natural size).

are more scalerows on neck, 33 instead of 25-31 in *brookei*. There is a single labial entering orbit, two in *brookei*.

It has been compared with *fasciatus* but the differences are about the same—there being only five or six small maxillary teeth in this form.

When compared with *caerulescens* the head is much too small, the body too slender anteriorly, and the number of teeth too small (14 to 18 in *caerulescens*).

Until a series of specimens is available from this locality (Bangphu, Bangkok) the proper disposition of this specimen will remain in doubt. Not included in key.

Family VIPERIDAE Boie

Viperidae Boie, Isis, 1827, p. 511.

Diagnosis: Maxillary bone vertically elongated bearing only a large tubular poison-fang on its posterior part. Hypapophyses present throughout the vertebral column.

Only a single genus *Vipera* of this family is known to enter Thailand and even this has only a very limited distribution.

Genus *Vipera* Laurenti

Vipera Laurenti, Synopsis reptilium, 1768, p. 99 (type of genus, *redi* = *aspis*).
Daboia Gray, Zoological miscellany, 1842, p. 69 (type of genus, *pulchella* = *russellii*).

Diagnosis: Head distinct from neck, the top covered with small scales, without enlarged frontal or parietals; eye with a vertical pupil; a very large nostril pierced in a rather large lateral nasal shield; a nasorostral shield between nasal and rostral, or partially united with the nasal. Scales in 19-33 rows around body; ventrals rounded, tail short.

The genus is confined to Europe, Africa, Asia, and the Indo-Australian Archipelago.

Vipera russellii (Shaw)

(Fig. 119)

Coluber russellii Shaw, Naturalists miscellany, vol. 8, 1797, pl. 291 (Based on a figure in Russell's Indian serpents [Katuka Rekula Puda], p. 10, pl. 7) (type-locality, by inference, Coromandel Coast).

Several subspecies have been recognized by various authors, *russellii siamensis* being the only representative known in Thailand.

Vipera russellii siamensis M. Smith

Vipera russellii siamensis M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 482-485, fig. 153.

Diagnosis: A large species reaching approximately one and a half meters in length; similar to *russellii rusellii,* but differing in details in markings on head. An additional series of small elongate black spots present between the dorsal and lateral series, and small irregular spots along the flanks.

Description of subspecies: Snout bluntly rounded in profile; nostril very large; the diameter of eye about equal to distance of

eye from nostril, less than its distance to mouth; rostral small, not visible from above; a nasorostral scale between rostral and nasal, partly united with nasal below, separated above; supraocular small slender; six to nine scales between supraoculars; ten to fifteen small scales surround eye. Head scales small imbricate and keeled; several rows of temporals, lower largest and smooth, others strongly keeled; ten to twelve supralabials, separated from eye by three rows of small scales; mental small; two pairs of chinshields, an-

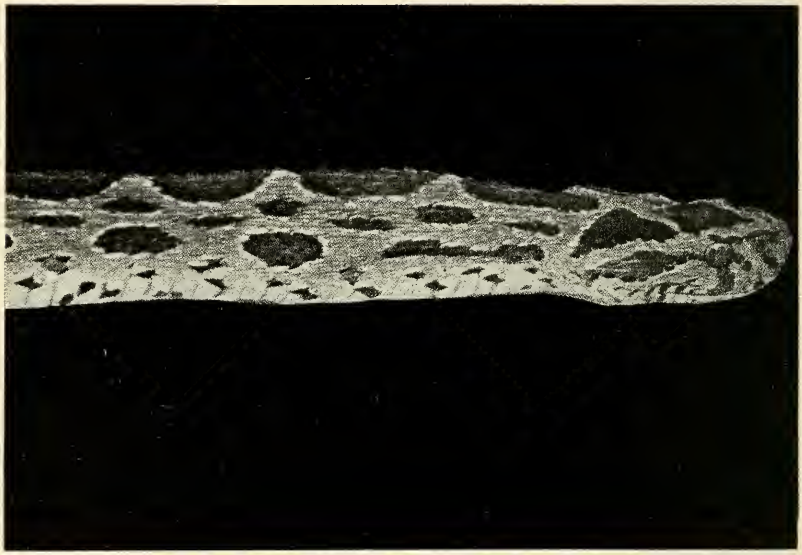

FIG. 119. *Vipera russellii siamensis* M. Smith. From M. Smith, Journ. Nat. Hist. Soc. Japan, vol. 2, No. 3, pl. fig. 1.

terior double size of second, separated by a pair of small scales; twelve or thirteen infralabials, four or five touching the anterior chinshields, maxillary with a large fang.

Scalerows: 25-29; 27-33; 21-23, all, except a smooth outer row, strongly keeled; ventrals, 153-180; caudals, 41-64, paired.

Color: Light brown to buff brown with three longitudinal rows of oval spots usually brown in the center with a border of black, edged with light buff-white. Occasionally spots touch or fuse; a row of small black spots between dorsal and lateral spots. Yellowish white on venter uniform or with semilunar black spots; small irregular black spots along flanks.

Measurements in mm.: Total length, 1270; tail, 210; specimens reported reaching more than one and one-half meters (measurement of a specimen given by M. Smith, *loc. cit.*, p. 484).

Distribution: In Thailand the species is known only in a small area north of Bangkok extending to Lop Buri and Nakhon Ratchisima. It is unknown elsewhere in the country. Isolated populations appear capriciously in areas in the Indo-Australian Archipelago, which have been recognized by subspecific names.

Family CROTALIDAE Gray

Crotalidae Gray, Ann. Philos., 1825, p. 204.

Diagnosis: Maxillary bone excavated by a deep fossa, which opens externally; fang not grooved in front; a postfrontal bone.

I recognize two subfamilies *Crotalinae* and *Lachesinae.*

Subfamily LACHESINAE Cope

Lachesinae Cope, Rep. U. S. Nat. Mus., 1898 (1900), p. 113.

Diagnosis: Characters of family; no jointed epidermal caudal appendage.

This group is widespread in both hemispheres.

KEY TO THAI GENERA OF THE LACHESINAE

1. Nine normal symmetrical head shields ..... *Agkistrodon*
2. Upper part of head covered for the most part with small scales except for presence in some species of supraoculars ..... *Trimeresurus*

Genus *Agkistrodon* Palisot de Beauvois

Agkistrodon Palisot de Beauvois, Trans. Amer. Phil. Soc., vol. 4, 1799, p. 381 (type of genus, *A. mokasen*).

Leiolepis Duméril and Bibron, Mem. Acad. Sci. Fr., vol. 23, 1853, p. 534 (type of genus, *Trigonocephalus rhodostoma*) (not of Cuvier).

Calloselasma Cope, Proc. Acad. Nat. Sci. Philadelphia, 1859, p. 336 (Substitute name for *Leiolepis* preoccupied).

Diagnosis: Pit vipers with dorsal head scales complete or nearly so; eye with a vertical pupil; maxillary with a very large fang but no other teeth. Hypapophysis developed throughout vertebral column; a lateral sensory pit on snout; body nearly cylindrical; scales smooth or keeled; tail moderate or short; subcaudals paired or some (or all) single; anal entire; third and fourth supralabials largest, in contact with subocular which may or may not be divided.

Only a single species of the genus occurs in Thailand. It is widespread in the country and is one of the dangerous snakes, though not necessarily a deadly one. Its color in grays and browns makes it difficult to see on the ground. Often it is not frightened by the presence of human beings. One specimen crawled into my camp, while I was moving about and paid little or no attention to my presence.

Agkistrodon rhodostoma (Boie)

(Fig. 120)

Trigonocephalus rhodostoma Boie, Isis, 1827, p. 561 (type-locality, Java); Schlegel, Essai sur la physionomie des serpents, vol. 2, 1837, p. 547, pl. 20, figs. 1-3; Jan and Sordelli, Iconographie générale . . . livr. 46, 1874, pl. 6, fig. 2.

Ancistrodon rhodostoma: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, pp. 527-528; Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 170; A vertebrate fauna of the Malay Peninsula; Reptilia and Batrachia, 1912, pp. 213-214, fig. 64; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 164 ("Patani"); Journ. Bombay Nat. Hist. Soc., vol. 23, 1915, p. 788; Gyldenstolpe, Küngl. Sven. Vet-Akad. Stockholm; vol. 55, 1916, p. 27; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 279-281, figs. 114-115; Tweedie, The snakes of Malaya, 1954, pp. 114-115, pl. 10, text fig. 26, a, b.

Agkistrodon rhodostoma: Barbour, Mem. Mus. Comp. Zool. Harvard Coll., vol. 44, 1912, p. 139; Cochran, Proc. U. S. Nat. Mus., vol. 67, 1930, p. 37; Bourret, Les serpents de l'Indochine, 1936, p. 452-454, fig. 179; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1168 (Sakon Nakhon).

Ancistrodon annamensis Angel, Bull. Mus. Nat. Paris, ser. 2, vol. 4, 1933, p. 277-278, fig. (type-locality, "Vinh Hoa, South Annam").

Agkistrodon annamensis: Bourret, Les serpent de l'Indochine, vol. 2, 1936, p. 454.

Calloselasma rhodostoma: Günther, The reptiles of British India, 1864, pp. 391-392; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, pp. 37, 63.

Diagnosis: Stout-bodied snake rarely reaching more than 700 mm. in length; head large triangular; snout pointed; two anterior temporals, lower the larger; formula of scalerows: 21, 21 (19), 17 (15). Head with nine typical head scales above; a sensory pit between eye and nostril; an elongate subocular, touching two labials.

Description of species (from No. 35679; near Rompibon, [Tonka Harbor Tin Mine], Nakhon Si Thammarat): Head strongly triangular; the snout turned up slightly at tip; rostral as wide as high, not or scarcely visible from above; internasals little more than one third of area of prefrontals; frontal rather small, its length a little less than its distance from end of snout, shorter than parietals, slightly wider than supraoculars; nasal partially or wholly divided, anterior portion the higher and equal or greater in area than posterior; latter pointed at its posterior end; a canthal (loreal) precedes preocular; a rather large scale forms anterior border of sensory pit; lower preocular divided vertically, forms lower border of sensory pit, middle preocular, the upper border; subocular elongate, curving diagonally, separated from supraocular by a single postocular; two large and two small superimposed anterior dorsal temporals; three secondary temporals; seven (eight) supralabials, third

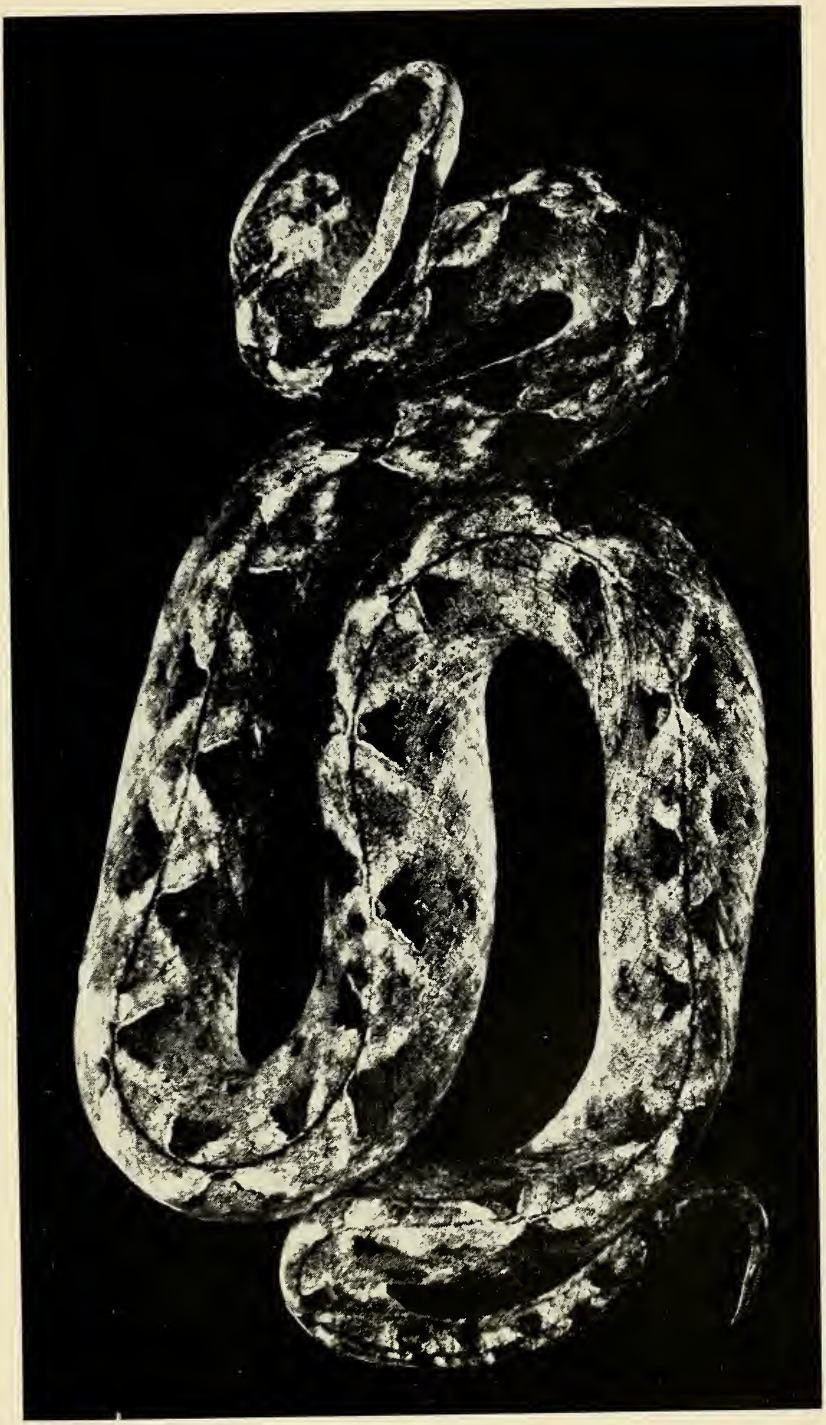

FIG. 120. *Agkistrodon rhodostoma* (Boie). No. 35624, Ronpibun, Tin Mine, Nakhon Si Thammarat province. Actual total length, 681 mm.; tail, 84 mm.

and fourth bordering subocular; eleven infralabials, first three bordering first pair of chinshields which are considerably larger than second or third pairs.

Scale-formula: 35 (occiput), 23, 22, 17; scales with two apical pits. Ventrals, 155; divided subcaudals, 39, (the terminal one single, elongate, [6 mm.], hornlike); anal, single.

Color: Head gray-brown with a light, dark-bordered stripe on each side; an elongate temporal spot, its lower edge bordered with a black and a white line forming a festooned pattern; below this line and forward the labials are grayish; body variable brownish gray with a series of paired dark-brown spots edged on two sides with a narrow blackish line bordered by a bluish-white line, the spots touching or narrowly separated on middorsal line. A very narrow black middorsal stripe. Venter brownish white clouded or peppered thinly with pigment.

Measurements in mm.: See table.

Table of measurements of Thai *Agkistrodon rhodostoma*

NUMBER	35679	210	209
Sex	♀	♂	♂
Snout to vent	638	608	589
Tail	74	68	78
Width of head	29	28	29
Length of head	42	35	37

Variation: The known variation in ventrals is: male, 148 to 154; female, 156 to 166; subcaudals, male 45 to 52; females, 35 to 46 (*fide*, M. Smith). Of the two measured specimens (Nos. 209-10) the female has fewer ventrals (154; male, 157), and a larger number of subcaudals (42; male, 37?) which is probably not the usual condition in specimens from the same locality (Na Bon, Nakhon Si Thammarat).

Distribution: In Thailand specimens are known from Lop Buri, Sakon Nakhon, Korat, Chiang Mai, Nakhon Si Thammarat, Trang and Puket. It would appear to be distributed throughout the country save in the higher areas.

Outside of Thailand the species is known in Indo-China, Malaya, and Java.

Remarks: The native name for this serpent is *ngu maaw-sao* and *ngu kaba.* Its dangerous character is well known.

The Pasteur Institute in Bangkok prepares an antivenine specific for this snake. The actual number of deaths from bites of this species is not great. Malcolm Smith who had a long experience with snakes in Thailand regards the bite as rarely fatal. He says (1947, p. 480): "Deaths have been recorded, but they are extremely rare and they appear to have been caused by septic conditions secondary to the bite. In the vast majority of the cases the symptoms are not severe and are quickly recovered from."

Genus *Trimeresurus* Lacépède

Trimeresurus Lacépède, Ann. Mus. Paris, vol. 4, 1804, p. 209 (type of genus, *viridis*).

A number of other generic names have been proposed, based on species not occurring in Thailand.

Diagnosis: Head very distinct from neck, its upper surface largely covered with small scales; a deep pit on side of the snout; vertical pupil in a moderately small eye; large poison-fangs present on a movable maxillary. Tail prehensile or not. Dangerous (although not necessarily deadly) to man.

There are nine species known to occur in Thailand, all but one (*monticola*) being arboreal (or at least semiarboreal). *Monticola* is a terrestrial species and is oviparous. Most if not all of the other Thai species are ovoviviparous.

KEY TO THAI SPECIES OF *Trimeresurus*

1. Twelve to fourteen strongly keeled scales between small supraoculars; nine to ten supralabials, first free from nasal scale, second not bordering loreal pit ..... *wagleri*
   Nine to fifteen obtusely keeled or smooth scales between supraoculars; second labial borders loreal pit; first fusing with nasal or separated from nasal 2
2. First supralabial completely separated from nasal, tail prehensile or not ... 3
   First supralabial partly or completely joined to nasal, tail prehensile or not 7
3. Head-scales flat, partly imbricate, larger; five to eight scales (rarely nine) between large supraoculars 4
   Head-scales smaller, subimbricate, nine to thirteen scales between narrow supraoculars 5
4. Head short; tail not prehensile; seven to ten supralabials; two to four rows of scales between supralabials and subocular. Brown with large spots of darker brown; scalerows at mid-body 23 to 25 (very rarely 27); 132 to 158 ventrals ..... *monticola*
   Head elongate, tail somewhat prehensile; one or two rows of scales between labials and subocular (or third labial may touch subocular); scalerows at mid-body, 21; larger snake ..... *sumatranus*
5. General color green with a lateral light stripe on outer scalerow bordered above by an orange or chocolate-brown stripe 6
   General color brownish-gray with a dorsal series of irregular brown spots, smaller spots on sides; whitish below; scalerows 19, 19, 15 ..... *kanburiensis*

6. Hemipenes strongly spinose ..... *stejnegeri*
   Hemipenes without spines ..... *popeorum*
7. General color, green in life 8
   Purplish-brown uniform, olivaceous or grayish above, variegated or spotted and marked with brown; 12-15 scales between narrow supraoculars; 11 to 13 supralabials; two to three rows of scales between supralabials and subocular ..... *purpureomaculatus purpureomaculatus*
8. Shorter thicker snakes, the temporals strongly keeled; scale-formula: 23 (or 25), 23 (or 25), 17 (or 19); 11 to 14 scales between narrow supraoculars; white line on outer scalerow in males but absent in females; terminal part of tail reddish in life (or brown mottled in preservative) ..... *erythrurus*
   Somewhat slender snakes; temporals feebly keeled. scale-formula: 21 (23), 21 (19), 15 (17); eight to twelve scales between undivided supraoculars; a light lateral whitish stripe, weak or absent in females; a light temporal stripe; tail not red or spotted ..... *albolabris*

Trimeresurus monticola Günther

(Fig. 121)

Parias maculata (not of Gray, 1842) Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 392 (Sikkim).

Trimeresurus monticola Günther, The reptiles of British India, 1864, p. 388, pl. 24, fig. B (type-locality, Nepal); Stoliczka, Journ. Asiat. Soc. Bengal, vol. 40, 1871, p. 445; Fayrer, Thanatophidia of India . . . 1874, pl. 15; Anderson, Anatomical and zoological researches and zoological results of the Yunnan Expedition, 1879, p. 832, pl. 76; Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 426; Miller, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, p. 729; Wall, Journ. Bombay Nat. Hist. Soc., vol. 30, 1925, pp. 251, 821; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, no. 1, 1923, p. 64 ("Doi Chiang Dao, Hills west of Chumphon"); Bull. Raffles Mus., no. 3, Apr. 1930, p. 90; Pope, The reptiles of China . . . 1935, p. 412, M. Smith, Proc. Zool. Soc., London, 1921, p. 427; Rec. Ind. Mus., vol. 37, 1935, p. 240; *ibid.*, vol. 42, 1940, p. 485; Bourret, Les serpents de l'Indochine, 1934, p. 457; Smedley, Bull. Raffles Mus., no. 6, 1931, p. 123; M. Smith, The fauna of British India . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 508-510, fig. 161.

Lachesis monticola: Boulenger, Catalogue of the snakes in the British Museum (Natural History), vol. 3, 1896, pp. 548-549; Annandale, Rec. Ind. Mus., vol. 8, 1912, pp. 50, 64; Venning and Wall, Journ. Bombay Nat. Hist. Soc., vol. 20, 1910, p. 343, 775; Wall, *ibid.*, vol. 18, 1908, p. 334; *ibid.*, vol. 19, 1909, p. 356; *ibid.*, vol. 21, 1911, p. 284; Rec. Ind. Mus., 1907, p. 157.

Trimeresurus convictus Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 224, pl. 12 (type-locality, West Hill, Penang).

Trimeresurus orientalis Schmidt, Amer. Mus. Nov., no. 175, 1925, p. 3 (type-locality, Shao-wu, Fukien).

Trimeresurus tonkinensis Bourret, Bull. Gén. Inst. Publ. Hanoi, 1934, p. 10; Les serpents de l'Indochine, 1936, p. 460 (type-locality, Chapa, Tongking).

Trimeresurus monticola meridionalis, Bourret, Bull. Gen. Inst. Publ. Hanoi, no. 9, 1935, p. 13; Les serpents de l'Indochine, 1936, p. 459, fig. (type-locality, Chapa, Tong-King).

Diagnosis: An egg laying, ground living, pit viper reaching a little more than one meter in length (1100 ♀); head scales smooth; first labial completely separated from nasal; subocular broken up into small scales; a pair of internasals; brown with darker brown spots; venter lighter, yellowish dusted with brown.

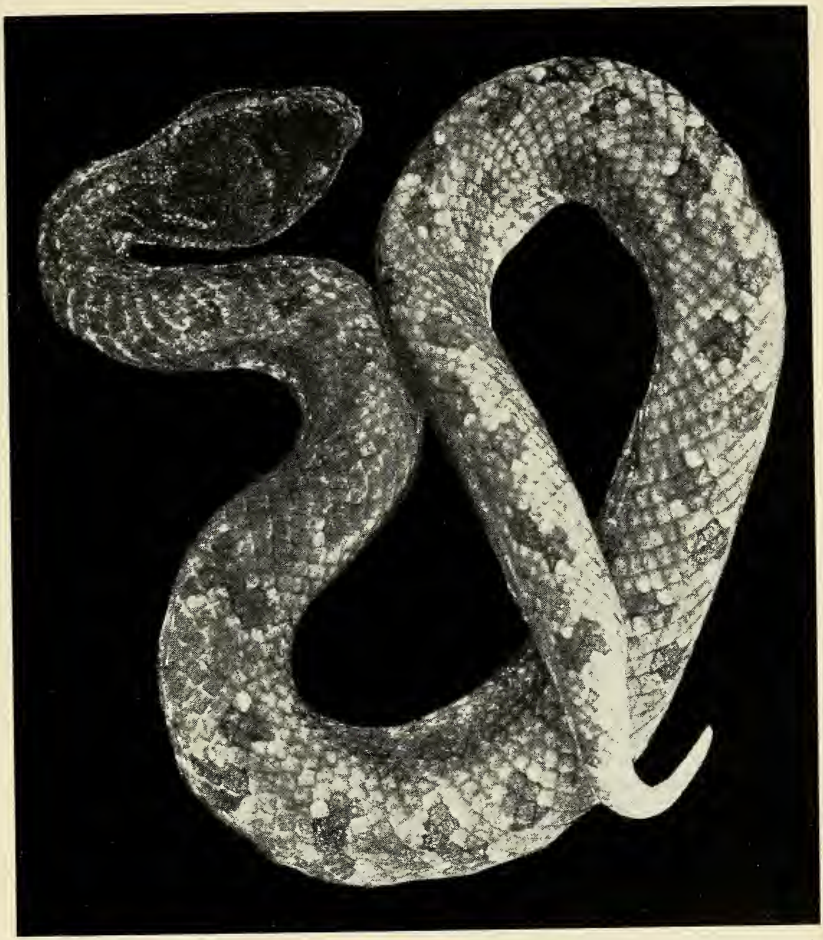

FIG. 121. *Trimeresurus monticola* Günther. EHT-HMS No. M.8, Fraser's Hill, Malaya. Actual total length, 666 mm.; tail, 58 mm.

Description of species (from EHT-HMS No. M.8, Fraser's Hill, Malaya): Rostral slightly wider than high, not or scarcely visible from above snout, bordered laterally by labial and nasal, posteriorly by three very small scales; a pair of internasals forming a short median suture; nasal large, partly divided by a suture entering on upper edge and reaching nostril; a large upper loreal below which is a second small loreal; this with second labial forms anterior border of nasal pit (second labial with a groove but no suture across upper border); three preoculars, two lower ones partly separated by pit; supraoculars large, separated by five rows of

irregular scales, median row largest; subocular short, partly broken into smaller scales; three small postoculars; eye small; pupil vertical; supralabials, 9-8, third largest, separated from subocular by two scalerows, from fourth labial by three rows; three or four rows of somewhat enlarged smooth temporals. Mental with a wider labial border than rostral; infralabials, 11-11, three touching first pair of chinshields; second pair of chinshields absent or no larger than other scales on chin.

Dorsal scales smooth, formula for scalerows: occiput, 40; neck, 23; middle, 23; before vent, 17. Ventrals, 138; anal, single; subcaudals, 23, the last two single.

Color: Above and on sides brown, darker anteriorly; top and sides of head blackish brown; a brown stripe behind eye; tail, light brown becoming greenish yellow on latter half; 22 dark brown spots along each side of median line, each covering four to six scales, sometimes paired, sometimes alternating, rarely fused; at border of each spot, several bordering scales may be cream or yellowish, covering one, rarely two, scales; a second row of spots indicated lower on side; venter dull yellowish, each ventral scale dusted with brown; yellowish color encroaching at times on outer scalerow; subcaudal area, light variegated brown, tip of tail greenish yellow. A yellow line crosses angle of mouth and continues a short way on neck; two yellow spots on infralabials extending on to the chin. Throat and chin light, dusted with brown.

Measurements in mm.: Snout to vent, 608; tail, 58; total length 666; width of head, 30; length of head, 41.

*Variation:** The extraordinary range of ventrals and subcaudals strongly indicate subspecific variation; several forms have been named (see synonymy).

The variation in ventral count is from 127 to 176; of subcaudals, 21 to 62; the scalerows around the body vary between 21 and 25 and may be feebly keeled instead of completely smooth; a second series of dark brown spots may be distinct, and another series at outer ends of the ventral scales (barely indicated in the described specimen); the markings on the young are more contrasting and distinct.

The second labial may be divided at the groove and this portion fused to the lower loreal; the scalerows between supraoculars may vary between 5 and 9.

* Malcolm Smith gives the following data: In specimens from eastern Himalayas, Assam, Burma, SE Thibet, Yunnan, and Siam, the range in 30 specimens is, ventrals, 137-176; subcaudals, 36-62; for Annam, Tongking, South China, 127-144: 36-54, Malay Peninsula, 133-137; 22-28.

Distribution: In Thailand known in Chumphon province. Elsewhere the species ranges from Nepal, Assam, and Burma through the eastern Himalayas east to Yunnan southern Thibet, Indo-China, and Malaya. The specimen described is from Fraser's Hill, Malaya. A specimen is known from Mt. Muleyit, Tenasserim, Burma. It is a high mountain form and may be looked for at proper elevation anywhere within the range given.

Remarks: The species unlike most members of the genus *Trimeresurus* lays eggs instead of giving birth to its young. In certain genera of reptiles it is the high mountain forms that give birth to their young, while the lowland members lay eggs.

Trimeresurus purpureomaculatus (Gray and Hardwicke)

Trigonocephalus purpureomaculatus Gray and Hardwicke, Illustrations of Indian Zoology, vol. 1, 1832, pl. 81 (based on a drawing by Hardwicke (type-locality, Singapore).

Two subspecies of this form are recognized: the typical form which is known in Thailand, and *andersoni* known only in the Andaman and Nicobar Islands.

Trimeresurus purpureomaculatus purpureomaculatus (Gray and Hardwicke)

Trimeresurus purpureomaculatus: Boulenger, The fauna of British India . . . Reptilia and Batrachia, 1890, p. 429; Proc. Zool. Soc. London, 1890, p. 36; Pope and Pope, Amer. Mus. Novitates, no. 620, p. 1933, p. 11.

Lachesis purpureomaculatus: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, p. 553 (*part.*).

Trimeresurus purpureomaculatus purpureomaculatus: M. Smith; The fauna of British India . . . vol. 3, Serpentes; 1943, pp. 520-521.

Trimeresurus acutimentalis Werner, Sitz. Akad. Wiss. Wien, vol. 135, p. 257 (type-locality, South India).

Diagnosis: Upper head scales small, granular, or tuberculate; supraoculars very narrow, sometimes broken up; first labial partly or completely joined to nasal; 25 to 27 scalerows around body; temporal scales keeled; head olive; head and tail brown spotted; a ventrolateral light line present or absent.

Description of species: Snout twice as long as diameter of eye; upper head scales small tuberculate; twelve to fifteen scales between supraoculars, which are narrow or broken up into small scales; internasals large, two or three times size of adjoining scales.

Rostral as deep as broad barely visible above; head-scales small, juxtaposed, tubercular or granular, convex or slightly keeled; internasals small, but two to three times larger than adjoining scales and separated from each other by one or two scales; two or three

postoculars and an elongate subocular; latter separated from supralabials by two or three rows of scales; eleven to thirteen supralabials; first usually fused wholly or partly with nasal, second forming anterior border of the pit; beyond fourth the scales are small; temporal scales keeled.

Scalerows: 25, 25(27), 19(21), strongly keeled. Ventrals, 160 to 179 in males; 168 to 183 in females; subcaudals, 74 to 76 in males; 56 to 63 in females; anal undivided. Tail prehensile. Snout twice as long as eye.

Color: Dark purplish brown, uniform or variegated with pale green; flanks usually pale green or spotted with that color, sometimes with a line or a series of pale, spots on outer scalerow. Olive or greenish white below, uniform or spotted with black.

Measurements in mm.: Male, total length, 665; tail, 125; female, total length, 900; tail, 140 mm.

Distribution: Southern Thailand, south of the Isthmus of Kra. Known also from Malaya and southern Burma.

Trimeresurus wagleri wagleri (Boie)

(Figs. 122, 123)

Cophias wagleri Boie, Isis, 1827, p. 561 (type-locality, Java).

Trigonocephalus sumatranus: Cantor, (not of Raffles) Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1042, pl. 40, fig. 9.

Lachesis wagleri: Boulenger, Catalogue of the snakes in the British Museum, 2nd Ed., vol. 3, 1896, p. 562; S. Flower, Proc. Zool. Soc. London, 1899, p. 696; Ridley, Journ. Straits Branch Royal Asiat. Soc., no. 32, 1899, p. 202.

Trimeresurus wagleri: Günther, The reptiles of British India, 1864, p. 388; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 218-219; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 164 (Pattani); de Rooij, The reptiles of the Indo-Australian Archipelago, vol. 2, Ophidia, 1917, pp. 286-288, fig. 117; Tweedie, The snakes of Malaya, 1954, pp. 116-117, pls. 11, 12 (excellent photographs); Sworder, Singapore Nat., no. 2, 1922, p. 73; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 90, "states that he has examined a specimen from 'Pangnga' on the mainland of peninsular Siam, just north of Puket."

Diagnosis: About 14 scales between supraoculars; all head scales strongly keeled; a pair of enlarged internasals; first supralabial separated completely from nasal; second labial not forming anterior border of sensory pit; third labial not in contact with subocular; third and fourth supralabials separated from suboculars by one row of scales; tail prehensile; green, with small paired yellow or reddish spots.

Description of species (from No. 34421, Na Pradoo, Yala): Head strongly triangular diameter of neck less than a third of width of

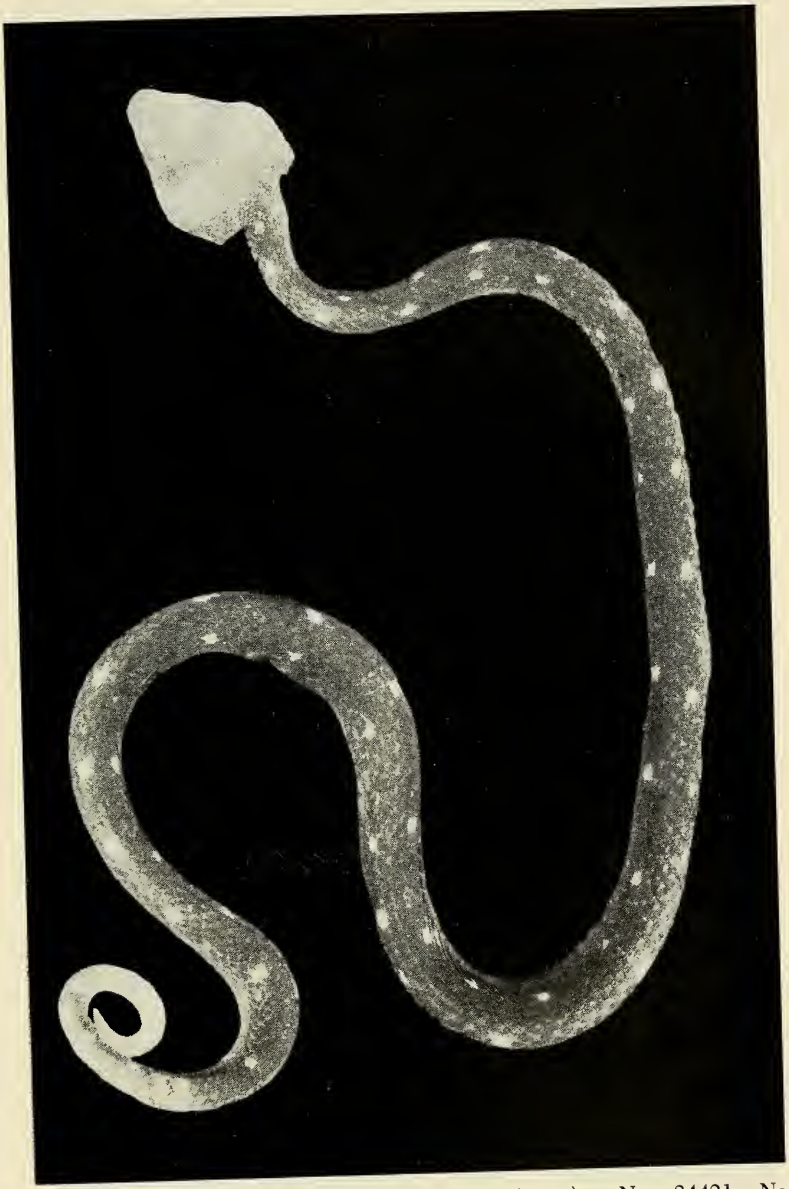

FIG. 122. *Trimeresurus wagleri wagleri* (Boie). No. 34421, Na Pradoo, Pattani, southern Thailand. Actual total length, 326 mm.; tail, 49 mm. (young).

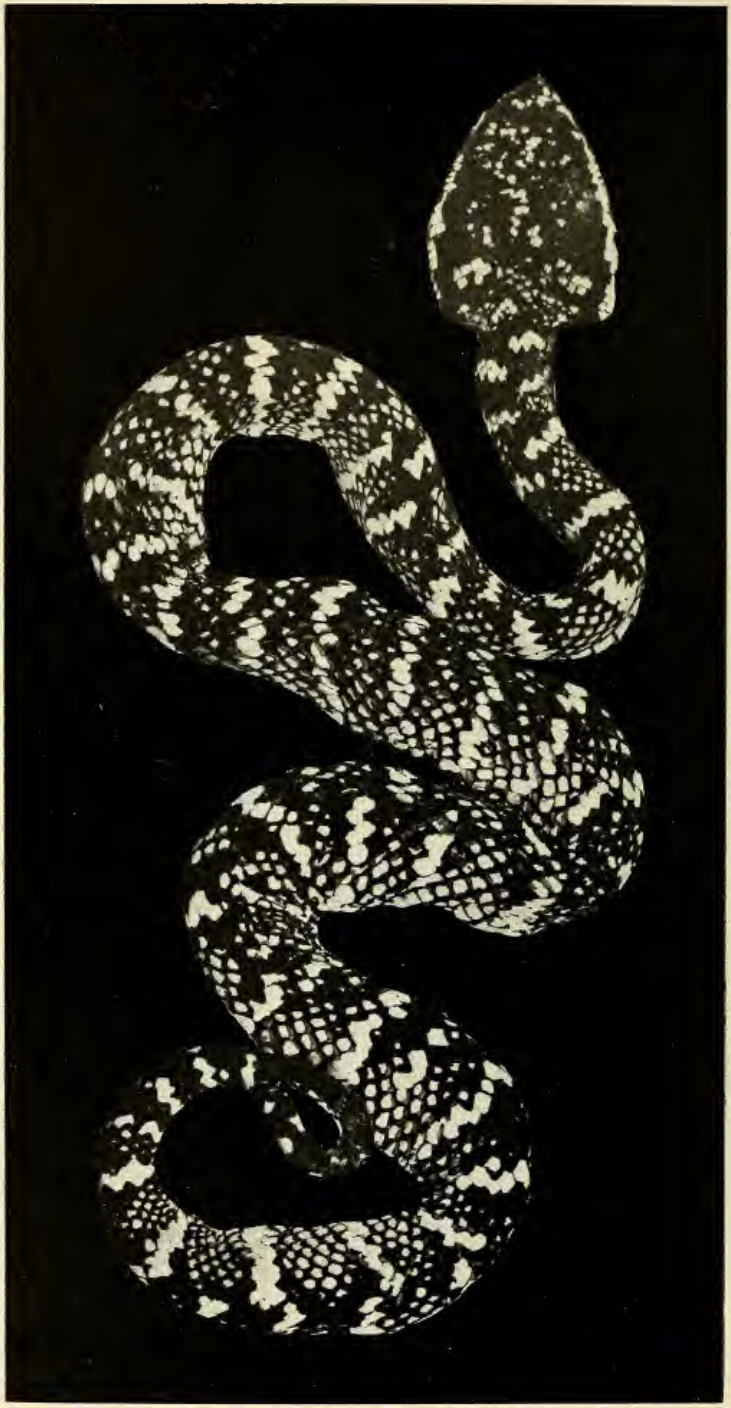

FIG. 123. *Trimeresurus wagleri wagleri* (Boie). No. 3476, Na Pradoo, Pattani province, southern Thailand. Actual total length, 676 mm.; tail, 103 mm. (adult).

head; rostral a little wider than high, standing vertically, visible above as a narrow line; internasals enlarged, three to four times size of adjoining head scales; about fourteen scales between supraoculars; all scales on head strongly keeled, and strongly imbricate; supraoculars two and a half times as long as wide; nostril in a single lateral nasal; two upper preoculars preceded by a canthal scale which in turn is separated by a scale from internasal; lower preocular not clearly differentiated, borders sensory pit below, while a large scale borders anterior part of pit; a large subocular; three postoculars; two small loreals between nasals and scale preceding pit; supralabials nine, third largest, none bordering elongate curved subocular; infralabials 11-12, posterior scales with tubercular keels; three border the anterior enlarged pair of chinshields which are followed by three equal-sized smaller pairs.

Scales about occiput, 47; about neck, 23; middle of body, 21; before vent, 17, all keeled except outer row. Ventrals, 147; single anal; subcaudals, 58 (divided). Diameter of eye half of distance from eye to middle point of snout.

Color: Green above with about 25 small paired yellow or yellowish-white spots usually edged with reddish, the pairs usually opposite each other, occasionally alternating. Tail reddish or yellowish with six or seven yellowish paired spots that may join on mid-line on posterior part of tail; a yellow or yellowish-white line on each side of head bordered by red or red-brown passing through eye; venter pale green with or without darker edges to ventrals; eye yellow.

Measurements in mm.: Total length, 326; tail, 49; head-width, 16; head-length, 18.

Variation: The coloration of the adult differs very much from that of the young. Tweedie (1954) describes one as follows: Adult black with scattered green spots above passing to green with the scales black-bordered on the sides; this pattern crossed by numerous cross-bars, green above, yellow on the sides; ventrals greenish white with irregular yellow patches, black borders and occasionally, black spots. Head black above with irregular green markings; lips and lower surface of head yellow and greenish-white, the scales with black sutures. Tail black, speckled with green above and below.

The ventrals vary between 127 and 154; the subcaudals, between 45 and 56. The anal is divided. The scalerows vary between 21 and 25; the supralabials between eight and ten. The number of scalerows between the supraoculars varies between eight and 14. The maximum length of the species is approximately one meter.

Remarks: Specimens are often seen in coastal areas, especially in the mangroves, swamps and with *Boiga dendrophila* it shares the name "Mangrove snake" or a native equivalent. In southern Thailand it is known under the Malay name of *ular bakaw.*

Distribution: The snake is known only in the southern Changwats of Thailand, specimens having been taken in Pattani, Yala and the island Phangnga. Outside of Thailand the snake is widely known in Malaya and the larger and most of the smaller East Indian islands extending into the Philippines and Celebes. These animals are rather sluggish. They may be captured by disturbing the tail with a cane or stick about which they will wrap their prehensile tail; then they may be lifted and carried considerable distances (a quarter mile or more) suspended from the stick.

Trimeresurus sumatranus (Raffles)

Coluber sumatranus Raffles, Trans. Linn. Soc., vol. 13, 1822, p. 334 (type-locality, Sumatra).

Trigonocephalus formosus Schlegel *in* Temminck, Verh. Nat. Ges. Ned. Ind. Rept., 1844, p. 52, pl. 7 (type-locality, Sumatra).

Bothrops formosus: Jan and Sordelli, Iconographie générale des ophidiens, livr. 47, 1875, pl. 5, fig. 1.

Lachesis sumatranus: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 557-558; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 217-218; de Rooij, The reptiles of the Indo-Australian Archipelago, vol. II, Ophidia, 1917, pp. 283-284.

Bothrops sumatranus: Lidth de Jeude, Notes Leiden Mus., vol. 8, 1886, p. 52, pl. 2, fig. 6.

Trimeresurus sumatranus: M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 268 (Kuala Teku, Malaya); Bull. Raffles Mus., no. 3, 1930, p. 90 (Pattani, Thailand); Tweedie, The snakes of Malaya, 1954, p. 117.

Diagnosis: Large species reaching more than a meter in length; scales between supraoculars smooth; gular scales smooth; snout not raised above nostrils; supraoculars large separated by from four to nine scales; scalerows at mid-body, 21; tail, prehensile.

Description of species (from literature): Head rather elongate; rostral as high as broad or a little broader than high; nasal partly or wholly divided; scales on top of head large, flat, smooth, imbricate, largest on snout, four to nine between large supraoculars; two or three postoculars; a subocular which touches third and often also fourth supralabials; temporal scales smooth; nine to eleven supralabials, first not fused to nasal; second forming anterior border of loreal pit; third largest.

Scales on dorsum in 21 rows, feebly keeled; ventrals, 180-190; subcaudals, 58 to 82; anal, single. Tail prehensile.

Color: Bright geen above, scales usually black-edged with or without cross-bands; two dorsal series of small whitish spots may be present on dorsum; a yellowish or whitish streak on outer scale-row; ventrals yellowish or greenish; scales with or without fine dark edges. End of tail red.

Measurements in mm.: Total length, 1100; tail, 180.

Distribution: The species is included in the Thai list on the basis of a report by Dr. Malcolm Smith, (1930)—"I have recently examined a specimen from Patani."

The species is widely distributed in Palawan, Borneo, Sumatra, Nias, Singapore and Malaya.

Trimeresurus albolabris Gray

(Fig. 124)

Trimeresurus albolabris Gray, Zoological miscellany, 1842, p. 48 (type-locality, China); Catalogue of the snakes in the collection of the British Museum, 1849, p. 8; Pope and Pope, Amer. Mus. Novitates, no. 620, 1933, p. 9; Pope, The reptiles of China, 1935, pp. 405-408, fig. 76, head; M. Smith, Rec. Ind. Mus., vol. 42, 1940, p. 485; The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1942, pp. 523-524.

Diagnosis: Similar to *T. erythrurus* but having a green tail neither reddish nor brown spotted, in having a higher average of combined ventrals and subcaudals (in females 231, male 238) as compared with 208 for Bangkok *erythrurus;* one loreal usually present, normally absent in *erythrurus.*

Description of species (from No. 3, Royal Forest Department): Rostral a little wider than high, visible above only as a narrow line; internasals larger than other scales, separated from one another mesially by a single scale; first supralabial fused with nasal; no loreal; second infralabial borders front of sensory pit; three preoculars, sensory pit partially separating the two lower scales; third supralabial touching subocular, fourth separated from it by one row of scales, fifth and sixth by two or three rows; supraoculars large, undivided, separated from each other by eleven or twelve scales; scale, preceding two upper preoculars, enlarged; scales on snout and top of head smooth, imbricating; temporal scales bluntly keeled; nine-ten supralabials; mental with a broader labial border than rostral, pointed behind, almost separating first labials from one another; first pair of chinshields largest, touching three supralabials; three other paired chinshields follow; twelve infralabials.

Scale-formula: 46 (occiput), 25, 21, 19, 15, all keeled except outer row and part of second row. ♀ Ventrals, 170; anal, single; subcaudals, 52. Tail prehensile.

FIG. 124. *Trimeresurus albolabris* Gray. A specimen from Thailand. About natural size. Locality uncertain.

Color: Head brownish with some lighter areas on scales about sensory pit, and on supralabials; body dark grayish with very numerous irregular transverse dark spots or bands, each more or less reaching venter except that it is broken by a whitish dotted line on outer scalerow; spots variable, sometimes confined to one ventral, sometimes to two or more; posteriorly outer part of ventrals all brown, middle third grayish (probably greenish white in life). One presumes the grayish areas also were green in life; lateral light stripe greenish white. Chin and throat dirty white; tail somewhat brown mottled.

Measurements in mm.: Snout to vent, 516; tail, 81; total length, 597; width of head, 22; length of head, 25.5; eye-length, 3.85; snout-length, 8.

Remarks: This specimen has the squamation of *Trimeresurus albolabris* while the coloration approaches that of *purpureomaculatus.* It is possible that with a series one might be able to separate this from *albolabris.*

Measurements in mm. and scale data on *Trimeresurus albolabris* (from Doi Suthep, Chiang Mai)

NUMBER	36548	36540	36547	36546
Sex	♀	♂	♀	♂yg.
Length	874	662	595	290
Tail	141	133	89	52
Scalerows, neck	27	23	29	26
Scalerows, body	21	21	21	21
Scalerows, before vent	15	15	15	15
Ventrals	172	167	169	164
Subcaudals	58	71	54	70
Loreal	0	1	1	1
Labial fused to nasal	yes	yes	yes	yes

Trimeresurus popeorum M. Smith

(Fig. 125)

Trimeresurus elegans: Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 391 (*nec* Gray, 1849).

Trimeresurus gramineus: Pope and Pope, Amer. Mus. Nov., no. 620, 1933 p. 3.

Trimeresurus popeorum M. Smith, Journ. Bombay Nat. Hist. Soc., vol. 39, p. 730; The fauna of British India, including Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1945, pp. 518-519 (the original spelling *popeiorum* is a clerical error).

Diagnosis: First labial completely separated by a suture from nasal; two loreals; second labial forms anterior boundary of facial

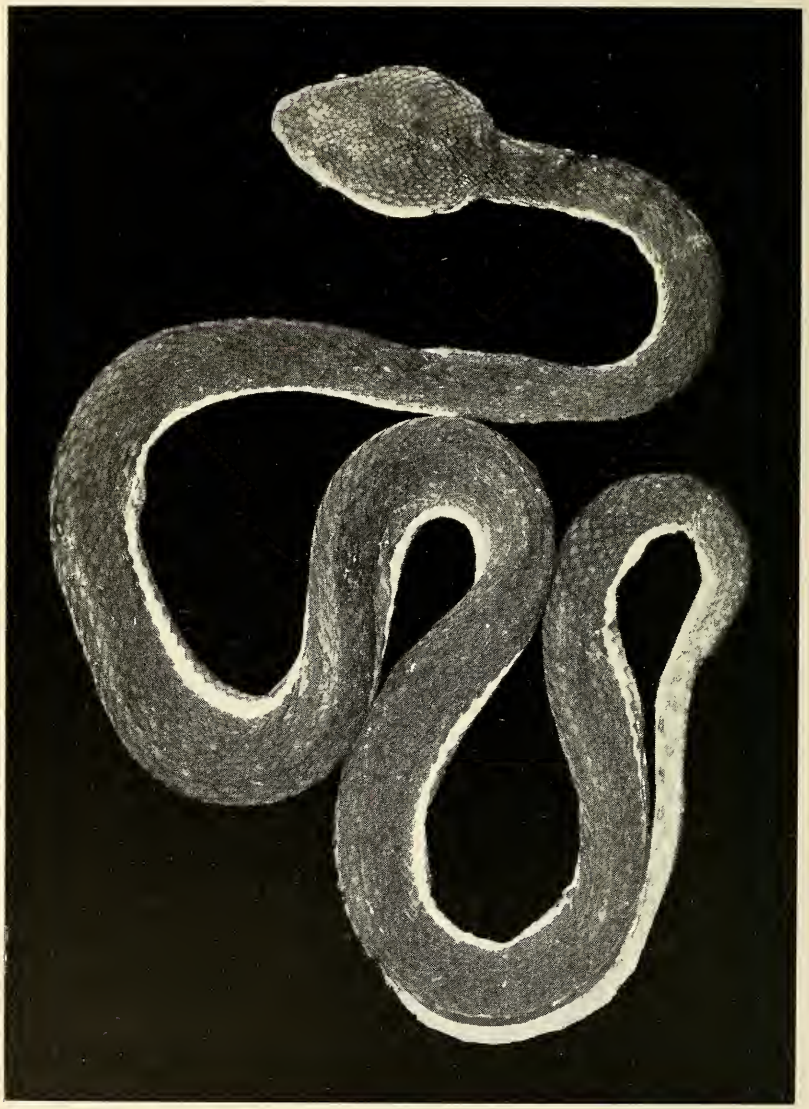

FIG. 125. *Trimeresurus popeorum* M. Smith. EHT-HMS No. 31800, Phu Nam Lang (Mt.) 1780 m. elev., Ban Khok, Na Phung, Dan Sai, Loei, province, central Thailand. Actual total length, 412 mm.; tail, 69 mm. (From Taylor and Elbel.)

pit; labials separated from subocular by none or by only one scale; body with dimly keeled scales for part of its length. A lateral salmon stripe and two series of cream or white marks.

Description of species: Rostral triangular, wider than high, can be seen from above only as a short narrow line, in contact with a small median scale; nostril pierced in a large nasal the two scales very narrowly separated by upper tip of rostral; nine supralabials, first completely separated from nasal, second high forming anterior border of facial pit; third largest touching elongate subocular, fourth, fifth and sixth supralabials separated from subocular by single scales; three elongate preoculars, two lower forming upper lower and posterior borders of facial pit; two small loreals; three small canthal scales border upper edge of nasal; supraocular elongate, irregular on left side, separated from posterior (fourth) canthal, but on right side divided, the anterior portion fused to last canthal; about 15 scales in a row between supraoculars; three or four rows of temporals somewhat enlarged, a few having faint keels; 28 scales between posterior supralabials; mental an equilateral triangle; infralabials, 11-12, the first pair in contact, three bordering first chinshields; two chinshields following separated by one or two scales.

Scale-formula: 32 (between ends of fifth ventral), 21, 21, 15; ventrals, 164; subcaudals, 72; some dorsal scales more or less keeled.

Color in life: Above a deep green; under a lens each dorsal scale shows some deeper green that appear blackish in fixative; head a shade of olive-green; a salmon or rusty red line begins on lower preocular, passes back along side of head behind angle of mouth, then down to first (outer) scalerow where each scale has this color except at tip where there is a regular cream spot; lower part of each scale of second row greenish white, later becoming cream. On base of tail a single cream zig-zag line bordering salmon which now appears only on outer edge of subcaudals. Tail above green with numerous dim dull-brownish spots or flecks; tip of tail lighter; venter green, edges of most scales showing a minute edging of white.

Measurements in mm.: Total length, 710; snout to vent, 577; tail, 133; width of head, 22; length of head, 30; diameter of neck, 9.

Variation: A small female specimen, also taken on Doi Suthep, has 12 scales between the undivided supraoculars. The internasals are separated by a single scale, and there are two loreals. The supralabials are separated from the subocular by a single scalerow.

The third supralabial may or may not touch the scale. There are 10-10 supralabials, 12-12 infralabials. The scale-formula: 21, 21, 15; 166 ventrals and 67 subcaudals. The color is practically identical with the specimen described.

Smith gives the following variation in 6 males: Ventrals, 161 to 172; subcaudals, 71 to 79; females, 157 to 169; 58 to 74. Scale-formula: 21 (23), 21, 15 (17).

Distribution: In Thailand the species has been taken in northern Thailand, Chiang Mai and Chiang Rai. Elsewhere the species is known in the eastern Himalayas, Assam, Burma, Malaya, Borneo and Sumatra.

Trimeresurus stejnegeri K. Schmidt

Trimeresurus gramineus: Boettger, Ber. Senck. Ges., 1894, p. 135 (Hainan); Stejneger, Bull. U. S. Nat. Mus., no. 58, 1907; Proc. U. S. Nat. Mus., vol. 66, 1925, p. 101.

Trimeresurus stejnegeri K. Schmidt, Amer. Mus. Novitates, no. 157, 1925, p. 4 (type-locality, Shao-Wu, Fukien, China); Bull. Amer. Mus. Nat. Hist., n. 54, 1927, p. 546, fig. 22; Pope and Pope, Amer. Mus. Novitates, no. 620, 1933, p. 5; M. Smith, The fauna of British India, Ceylon and Burma . . . vol. 3; Serpentes, 1943, pp. 517-518.

Trimeresurus gramineus stejnegeri: Stejneger, Proc. U. S. Nat. Mus., vol. 72, 1927; Pope, Bull. Amer. Mus. Nat. Hist., vol. 58, 1929, p. 478; Mell, Lingnan Sci. Journ., vol. 8, 1931, p. 218.

Trimeresurus stejnegeri stejnegeri: Pope, The reptiles of China, vol. 10; Nat. History Central Asia, 1935, pp. 418-422, fig. 77.

Lachesis gramineus: Boulenger, Catalogue of the snakes in the British Museum, vol. 3, 1896, pp. 554-556.

Diagnosis: First labial completely free from nasal; supraoculars narrow; dorsal scales keeled; head uniform green; hemipenes spinose; scalerows 21 or 19; ventrals, 155 to 169; a light ventrolateral line bordered by orange or chocolate; small white vertebral spots may be present.

Description of species: Rostral about as high as wide, small, sloping forward and upwards; upper head-shields smooth, flat; internasals not especially enlarged; seven scales bordering nasals; ten or eleven supralabials, first completely separate from nasal, second bordering loreal pit in front, third largest, touching subocular; supraocular transversely divided; two preoculars; an elongate curved subocular; two or three postoculars; supralabials behind third, separated from suboculars by two rows of scales; ten or eleven infralabials, three touching first chinshields; no second pair; numerous small scales between chinshields and first ventral.

Scalerows: 25, 21, 19, 15; ventrals, 155 to 169; subcaudals, 61 to 68.

Color: Light to dark green above, pale green to whitish below; a ventrolateral yellowish or whitish line bordered above by orange or chocolate brown; each ventral with a narrow posterior white margin; tip of tail brownish or pinkish; no light or dark markings on side of head; lip greenish.

Measurements in mm.: Total length, 750; tail, 145.

Distribution: There is only a single Thai record of this species, this from Hup Bon southeastern Thailand. It is known from Yunnan (China), Darjeeling (India), Assam and (?Upper Burma). M. Smith refers Burmese specimens having a scale-formula of 17, 17, 13, to this species. Their ventral count is 143 to 149, subcaudals, 57 to 60.

Remarks: The preceding description is derived from accounts of this species by K. Schmidt, Pope and M. Smith. The Thai specimen is a male with a scale-formula: 21, 21, 15; ventrals, 161; subcaudals, 65.

Trimeresurus erythrurus (Cantor)

Trigonocephalus erythrurus Cantor, Proc. Zool. Soc. London, 1839, p. 31 (type-locality, Ganges delta).

Trimeresurus erythrurus: Pope and Pope, Amer. Mus. Novitates, no. 620, 1933, p. 8; M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 386-523, fig. 165.

Trimeresurus bicolor Gray, Ann. and Mag. Nat. Hist., ser. 2, vol. 12, 1853, p. 292 (type-locality, India).

Trimeresurus carinatus Fayrer, The Thanatophidia of India, 1874, colored pl. 13.

Trimeresurus albolabris: M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, pp. 523 (*part.*).

Diagnosis: A rather stout snake, snout twice as long as eye (or a little longer); approximately 12-14 scales in a line between supraoculars; internasals large, separated by a single scale or in contact; first supralabial united with nasal; all or at least part of supralabials separated from subocular by two scalerows; scalerows, 21-25 about middle of body. Tail reddish to reddish brown above; when preserved (fomalin transferred to alcohol) color, dull lavender brown; chin and ventrals whitish; interstitial skin whitish.

Description of species (from No. 33543, Bangkok): Head broad, very distinct from neck; rostral slightly broader than high, in contact posteriorly with two broad internasals; latter scales nearly twice as wide as long; canthus distinct; internasal followed laterposteriorly by a scale a little larger than other scales on snout, and

this followed by an elongate scale lying above the "pit," touching two preoculars; supraocular not divided, separated from its fellow by from 11-13 scales; nasal single, pointed posteriorly; upper edge of nasal visible from above; no small loreals between nasal and second labial; supraoculars eleven, first fused with nasal; second forming front of sensory pit; third largest bordering third (lower) preocular and subocular; fourth separated from subocular by one scale, fifth and sixth separated from suboculars by two scales; two postoculars; pit surrounded by two lower preoculars and second labial; infralabials, 11-13 three bordering first chinshields; second chinshields smaller than first pair, followed by four paired scales, only second of which is separated by a small scale.

Scale-formula: 32 (occiput), 29, 21, 15; head scales strongly keeled, imbricate, pointed behind; dorsal scales sharply pointed on anterior part of body; median twelve rows more or less strongly keeled anteriorly, fewer rows posteriorly. Ventrals, 154; subcaudals, 54; anal, single.

Color in life: Above, head and dorsum dull yellow-olive to green, becoming reddish on tail; labials blue-green; (a narrow ultramarine line on outer scalerow continued to near tip of tail in male); chin blue, mixed with white; infralabials green; ventrals bluish anteriorly, yellowish green on sides gradually becoming more yellowish with a line of blue or ultramarine across each scale to vent; in subcaudal area, bluish to yellowish green, with a median diffuse line of magenta; eye yellowish. In preservative, lavender brown; side of head bluish white; lower part of supralabials white. Chin and ventral surface brownish white; outer edges of ventrals lavender; subcaudals largely same color as back, the scale edges whitish; skin between scales whitish.

Measurements in mm.: Total length, 712; tail, 117; body 6.08 times length of tail; width of head, 26.5; length of head, 32.

Remarks: Dr. Malcolm Smith has separated the Thai specimens, having the red to red brown tail and having 21 scalerows around body, from the Indian *erythrurus* (red tail) having 23 or 25 scalerows. I believe them to be the same.

Trimeresurus kanburiensis M. Smith

Trimeresurus kanburiensis M. Smith, The fauna of British India, Ceylon and Burma . . . Reptilia and Amphibia, vol. 3, Serpentes, 1943, p. 519 (type-locality, "limestone hills near Kanburi" [= Kanchanaburi]).

Trimeresurus puniceus: M. Smith, Journ. Nat. Hist Soc. Siam, vol. 7, 1928, p. 194; Bull. Raffles Mus., no. 3, 1930, p. 90.

Diagnosis: Supraoculars narrow; dorsal scales strongly keeled; head brownish; first supralabial completely separated from the nasal.

Description of species (from type-description): Snout twice as long as diameter of eye; upper head-scales small, subequal, feebly imbricate, smooth between eyes, keeled on back of head. Supraoculars rather large, transversely divided on their inner margins, eight scales between them; internasals twice as large as adjacent scales, separated by a single small scale; ten supralabials, first completely separated from nasal, third largest; a single series of scales between supralabials and elongate subocular; temporal scales small, obtusely keeled.

Scalerow-formula: 19, 19, 15, all strongly keeled; ventrals, 159; subcaudals, 42, paired; tail, prehensile; anal, entire.

Color: Brownish-gray, with a dorsal series of irregular brown spots, and smaller ones upon the sides; whitish on venter.

Measurements in mm.: Total length, 405; tail, 60.

Remarks: The type, a female, is unique, having been obtained in the limestone hills near Kanburi (Kanchanaburi) in the province of the same name.

This species resembles *I. puniceus*, which is a small member of the genus. It differs in lacking the raised canthus and the strongly keeled scales, and in being brownish-gray instead of reddish brown.

Puniceus has a strange habit of striking rapidly and repeatedly at nearby objects, sometimes as often as eight or ten times in five seconds! Nothing is known of the habits of *kanburiensis*.

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A Chemical and Limnological Study of Lake Vanda, Victoria Land, Antarctica

BY

ERNEST E. ANGINO

Department of Oceanography and Meteorology, Texas A. and M. University, College Station

KENNETH B. ARMITAGE and JERRY C. TASH

Department of Zoology, The University of Kansas, Lawrence

Lake Vanda (77°35′S, 161°39′E) lies in an enclosed basin near the center of Wright Valley (Figure 1). In January, 1961, the permanent ice cover was cored. The maximal depth of lake measured was 66 m., including the 4.2 m. ice cover. The bottom 6 m. were highly saline and were warmed to 25°C (Angino and Armitage, 1963; Armitage and House, 1962).

During Deep Freeze VI (1961-1962), Lake Vanda was visited at intervals during the antarctic summer months of November, December and January. Thirteen holes were cored through the ice. Sixty water samples were collected and returned to the University of Kansas for analysis. One hundred seventy-nine measurements of temperature and conductivity were made in the field. It was expected that both chemical analyses of these samples and the field measurements would provide sufficient data to aid in elucidating the problem of the source of the heat and the origin of the salinity.

The project was supported by National Science Foundation Grant G 18801 through the Office of Antarctic Programs. Larry Witt assisted in the field work and Curtis Ubele and Frank Escher with the chemical analyses. Personnel of Task Force 43 made the field work possible.

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FIG. 1.—Upper Wright Valley and Lake Vanda from the east. Open melt water is evident at the east end of the lake where the melt water stream from Wilson Piedmont Glacier enters the lake. Old shore lines are visible along the north shore. U. S. Navy Photo.

A. GEOGRAPHY AND MORPHOMETRY

The location of corings is shown in Figure 2. The mean depth (V/A), based on 14 soundings taken over a two-year period is 28.7 m. Presence of old shore-line features at least 55 m. above the present lake surface attest to a much larger lake in the recent past. The ice cover averages 4.2 m. in thickness. Similar ice thickness reported at Lake Bonney and on smaller lakes at Cape Royds (Armitage and House, 1962) suggest a local equilibrium between new ice formed yearly and that lost by sublimation. Comparable phenomena have been reported from high Arctic areas (Barnes, 1960). Additional morphometric parameters are listed in Table 1.

A major water source for Lake Vanda is melt water draining west from the Wright Valley tongue of Wilson Piedmont Glacier.

TABLE 1

Morphometric Parameters of Lake Vanda

A	= area = 13.6 km.^{2}
Zm	= maximum depth = 63 m. (without the 4.2 m. ice cover)
l	= maximum length = 8.5 km.
b_x	= breadth perpendicular to l = 2.4 km.
A/l	= mean breadth = 1.6 km.
V/A	= mean depth = 28.7 m. (without the 4.2 m. ice cover)
D_v	= development of volume = 1.37
L	= shore line = 25.2 km.
D_L	= development of shore line = $L/2\sqrt{\pi A}$ = 1.92

The geology of the general area has been ably described by McKelvey and Webb (1962).

ANALYTICAL METHODS

One liter samples spaced 3 meters apart were collected by means of a Kemmerer bottle attached to a sounding line. To test for any seasonal variations in the physical and chemical regimen of the lake, samples were taken from Hole 1 three times within a two-month period (18/XI/61, 28/XII/61 and 8/I/62). The pH of water samples was determined by a Beckman model G or N pH meter or with a Hellige Colorimetric Comparator as soon as possible after which the sample was transferred to polyethylene bottles for transport to the laboratory. Either a direct reading Whitney thermistor thermometer or an ordinary glass mercury thermometer determined temperature. Conductivity was measured in field by a custom-built Whitney conductance meter designed specifically for highly saline waters. These readings were later checked in laboratory by means of an Industrial Instruments conductivity bridge utilizing electrodes with cell constants of 1, 10 and 20. Following recalculation of all values to 25°C, a comparison was made between two sets of measurements. In general the laboratory values were *lower* than field data. Considering the instrumentation problems involved in measuring solutions of extreme salinity, the disagreement of values was not unexpected. The laboratory values are considered to be more correct and are

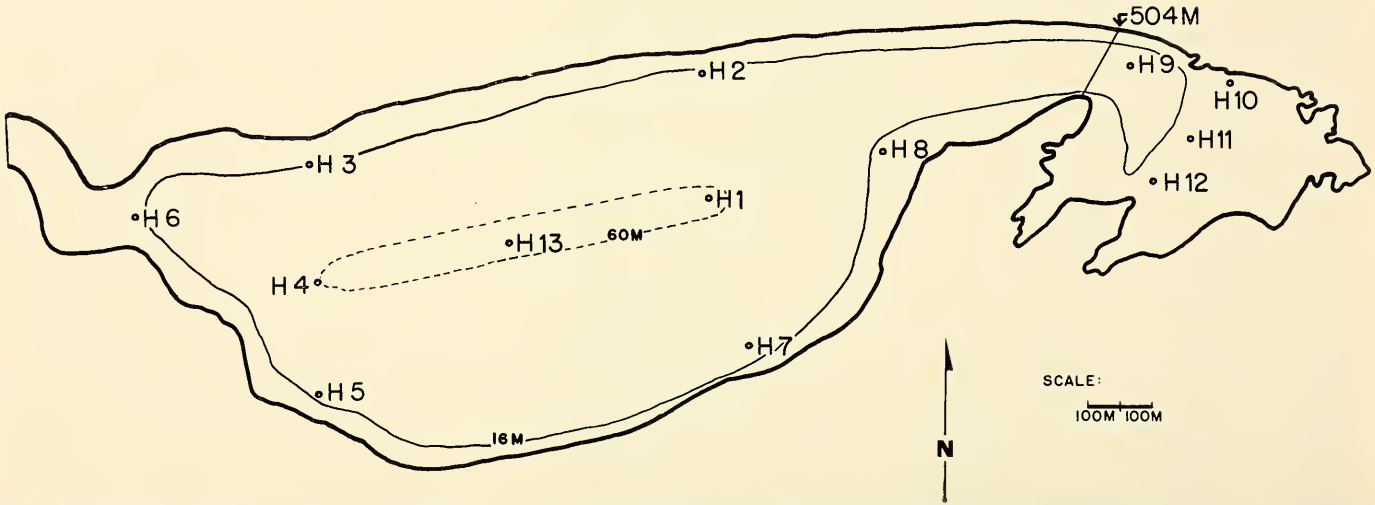

FIG. 2.—Map of Lake Vanda. The location of each coring is indicated by H followed by the core number; *e. g.*, H 1. The 60m contour is estimated. The line marked "504m" is a ground measurement.

used throughout. Chlorinity was initially determined by Mohr method and finally measured potentiometrically using $AgNO_3$. The latter method is more reliable for highly saline waters and repeated determinations to test reliability of measurements in these waters gave a reproducibility, by potentiometry, of $\pm$ 1%. Inasmuch as boron was present in amounts less than 5 ppm. in all the samples checked, no data for this element are presented.

Ca^{++} was detected by a potentiometric method utilizing HgEGTA as an indicator (Schmid and Reilley, 1957). This EGTA compound is not suggested owing to inherent unstable nature of HgEGTA. A specific endpoint for Strontium is not present, using this method, consequently the values reported as Ca^{++} should more correctly be considered as $Ca^{++} + Sr^{++}$. Standard potentiometric

TABLE 2

Methods of Chemical Analyses

Element	*Method*
Na^+	Flame Photometry $\pm$ 10% for waters $>$ 5000 ppm.
K^+	Flame Photometry $\pm$ 5% for waters $>$ 5000 ppm.
$Ca^{++} + Sr^{++}$	Back Titration with Hg EGTA (and EDTA). Reported as $Ca^{++} \pm 5\%$. See Schmid and Reilley, 1961.
Mg^{++}	Potentiometric with EDTA $\pm$ 2%.
Cl^-	Potentiometric with $AgNO_3 \pm 1\%$ for waters $<$ 50,000, $\pm$ 5% waters $>$ 50,000 ppm.
Li^+	Flame photometry.
B	Electrometric Titration Method with mannitol. (Standard Methods, 1955.)
Sulfate $SO_4^=$	Titrimetric method.
Silica SiO_2	Silicamolybdate (intermediate range). (Standard Methods, 1955.)
Fe	Phenanthroline method. (Standard Methods, 1955.)
N (NH_3)	Hyland Phenate-Hypochlorite Method. (Hyland Laboratories, Los Angeles.)
N (NO_2)	Diazotization Method. (Standard Methods, 1955.)
PO_4 (ortho)	Colorimetric, Amino-Napthol-Sulfonic Acid Method. (Standard Methods, 1955.)

methods using EDTA were employed to determine Ca + Mg, Mg was then determined by difference. Accuracy is about $\pm$ 2%. Table II lists the respective analytical methods employed to test for each constituent.

PHYSICAL DATA

Previous workers reported the presence of a warm (20-22°C) and saline monimolimnion in lower 6 meters of Lake Vanda. Our work during Deep Freeze VI (1961-1962) proved the existence of still warmer waters (25.5°C) in the deepest part of the lake (67.5 m.). Temperature profiles taken each time, from Hole 1, for the three months indicated are shown in Figure 3. A sharp thermocline occurs at 45 m. and a second, less sharp break, at 66 m. The high temperature of the monimolimnion of Lake Vanda immediately leads one to speculate as to a possible heat source.

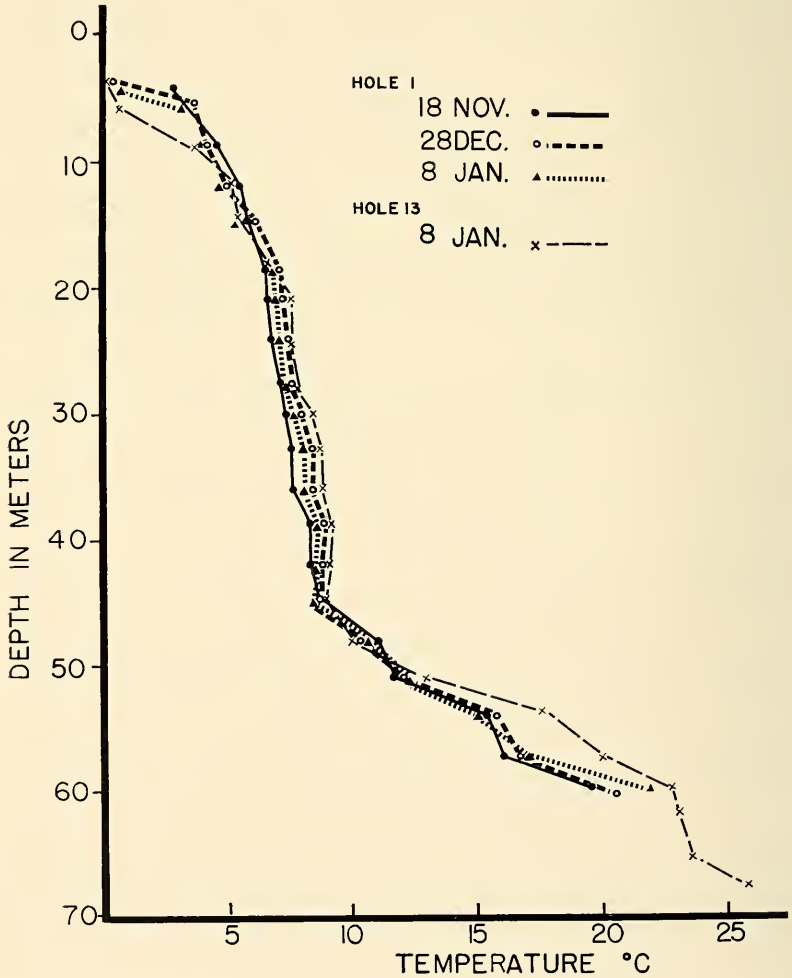

FIG. 3.—Temperature profile for Lake Vanda.

Solar radiation, geothermal gradient and volcanic hot springs as heat sources are most likely. Close examination of the temperature curves appears to rule out the first possibility. Actual *in situ* measurements indicate warmer water temperatures prevailing in some layers in November and December of 1961 than in January, 1962, both immediately beneath the ice and deeper. If we consider that by January 8, 1962, the summer sun was three weeks past its solstice, and had, in fact, been visible, excepting cloudy days of course, 24 hours a day for approximately three months, then surely more evidence of contribution of solar radiation to heating of upper waters would have been observed. No proof of this heating can be seen in the temperature data. With both the time of daylight and sun's angle decreasing steadily from January 8 onward, it seems quite unlikely that any increase in water temperature owing to solar radiation would occur. Inasmuch as Lake Vanda is surrounded by the steep rock walls of Wright Valley, it probably receives less radiation than would be normal in an open area. The November temperature data (Figures 3, 4) taken soon after return of the sun, suggests that the lake is thermally stratified throughout the year in essentially the pattern indicated by the thermal data reported.

Undoubtedly, some mixing of upper waters (20 meters or so) of the lake, owing to turbulent inflow of melt water from Wilson Piedmont Glacier occurs. Such a mixing is shown by minor variations in both temperature and chemical profiles. However, the effect of this stirring appears to be minor in early January, but probably is greater in late January when the inflow of cold surface water and its subsequent mixing tend to cool the upper 50 m. somewhat (Armitage and House, 1962). The temperature characteristics of the lake are exactly as would be predicted, if conductive heating from warmer bottom waters to the upper water is taking place.

This hypothesis is strengthened by a detailed study of temperature profiles from various parts of the lake (Figures 3, 4). Bottom temperatures in the vicinity of Hole 13 (measurement also by maximum-minimum thermometer to check thermistor type), are the highest recorded for any part of the lake studied (25.5°C). A plot (Figure 4) of isothermal lines on a longitudinal axis through Holes 6 — 4 — 13 — 1 — 9 and on two axes normal to the longitudinal axis (3 — 4 — 5 and 2 — 1 — 7) shows clearly the existence of a thermal dome centered in general area of Hole 4. Additional information concerning stability of this dome is evident in Figure 3

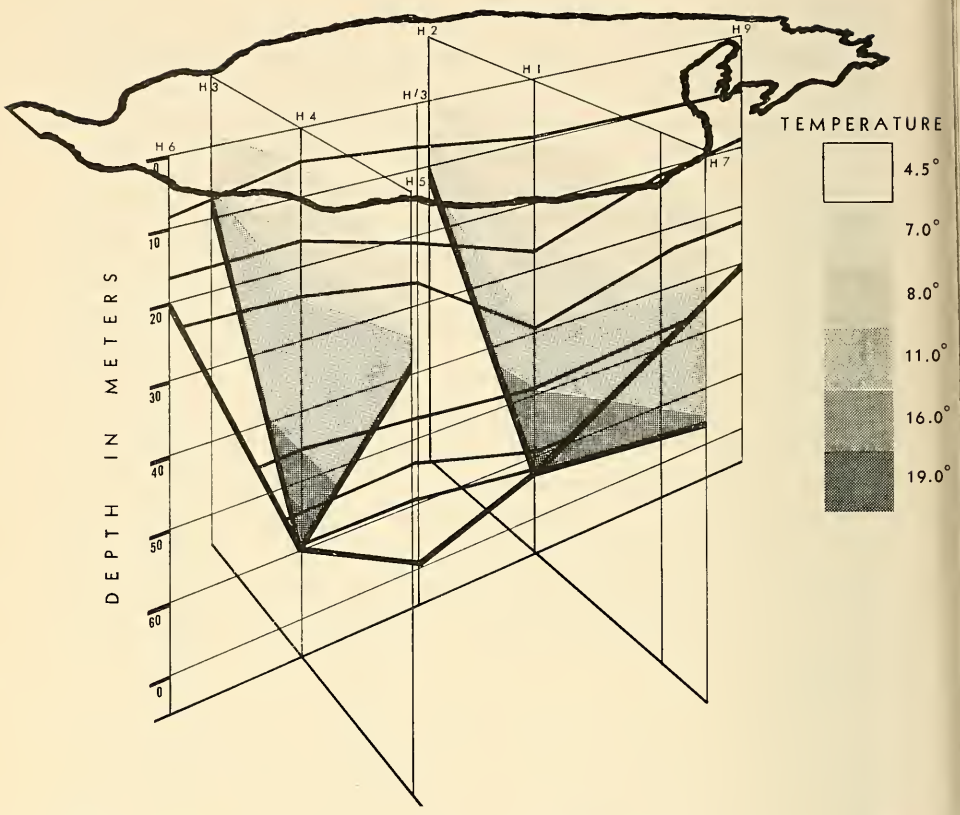

FIG. 4.—Three dimensional view of temperature distribution in Lake Vanda for November, 1961. Note the slight doming of isotherms in the general area of Hole 4.

where seasonal temperature profiles for Hole 1 are plotted and compared with data from Hole 13. The latter profile, near center of lake, between profiles 4 and 1, still shows this doming effect. Apparently the thermal dome is a relatively stable feature of the lake. Such a thermal doming suggests the inflow of some thermal water at this locality. These waters, of course, would also contribute to ionic content of lake.

Though solar radiation is not completely ruled out as a possible heat source by this analysis, it does seem rather difficult to explain the isothermal distribution patterns obtained by invoking a solar heating source.

A higher than normal geothermal gradient is also possible in this area, inasmuch as the lake is situated within presently active

Ross Sea volcanic province. The most likely heat source for the warm monimolimnion appears to be a combination of geothermal heat and heat introduced by volcanic hot springs.

A conservative calculation of amount of ice sublimated annually from the lake and consequently an indirect measure of amount of water concentrated yearly can be obtained by applying mathematical development of Barnes (1960).

The climatic parameters of primary value in estimating rates of ice formation and melting are the freezing and thawing indices F and M respectively. The freezing index is defined (Barnes, 1960) as the number of days in a freezing season that air temperature is below 0°C multiplied by average temperature of those days. Thawing index is the same only for days with temperatures above freezing. Approximate values of freezing index F_a can be calculated by multiplying the number of months that have mean temperatures below freezing by mean temperatures of those months and the mean number of days they contain. Detailed meteorological data from Wright Valley is limited; however, similar climatic conditions prevail in nearby Taylor Valley where some air temperature data are available (Angino, Armitage, Tash, 1962a). Utilizing these data and those of Péwé (1960), we derive the following expression for Lake Vanda:

$$[F_a = MoTmDa] = 11\ (16)\ (30.4) = F_a$$

where

Mo = months with average temperature below freezing
Tm = average temperature of those months
Da = average number of days they contain.

Perennial Ice

The thickness of a perennial ice sheet is controlled by a balance between the amount of ice that is lost off the top, and the amount of ice that forms at bottom. For any given climatic condition the amount of ice that forms at base of ice sheet decreases as ice grows thicker (Barnes, 1960).

Equations 1 and 2 show equilibrium relations between thickness, conductivity, temperature, and sublimation for bodies of ice that are thick enough to make their lower portions insensitive to change in annual air temperature (Barnes, 1960).

Rate at which an ice sheet thickens by crystalization at lower surface is given by:

$$\frac{dh}{dt} = \frac{1}{PL}\left(Ki - \frac{dTi}{dZ}\bigg| z = h - Kw \frac{dTw}{dZ}\bigg| z = h \right) \qquad (1)$$

where

Ki and Kw are conductivities of ice and water respectively

$\frac{dTi}{dZ}$ and $\frac{dTw}{dZ}$ are thermal gradients in ice and water.

L = latent heat of ice

d = density of ice

t = time

T = temperature

h = ice thickness.

The water just beneath the ice in Lake Vanda is essentially stably stratified and is both subject to little agitation by currents (excepting for approximately two months in summer) and well protected from excessive solar radiation (especially in winter by prevailing solar night and by thick ice cover). Studies on arctic area (Barnes, 1960) suggest that under these conditions the right hand term is very small and can be neglected.

Assuming a constant thermal gradient throughout the whole ice sheet, then (1) can be simplified to

$$\frac{dh}{dt} = \frac{A + KT}{PLh} \qquad (2)$$

where

A = amount of ice lost or added at upper surface of ice, and

T = mean annual temperature at top of sheet

K = thermal conductivity of ice.

Integration of (2) for A = 0, gives Stefan's formula for growth of an ice sheet for initial ice thickness of 0, or

$$h = \sqrt{\frac{2KT}{PL}\, t} \qquad (3)$$

When initial ice thickness is H, then

$$h = \sqrt{\frac{2K}{PL} Tt + H^2} \qquad (4)$$

where h = ice thickness after time t.

Maintenance of a perennial ice sheet requires that yearly summer sublimation is equal to amount of ice formed during following winter, so that:

$$A = \sqrt{\frac{2K}{PL} Tt + H^2} - H \qquad (5)$$

starting with equation (2a) (Stefan's equation) and assuming $A = 0$ (*i. e.*, no ice lost or added to surface) and assuming further a constant thermal gradient in the ice, that no heat is transferred to lower ice by radiation from water and that specific heat of ice may be neglected, then from equation (2):

$$-A = KT/PLh \qquad (6)$$
$$\text{or } h = -KT/PLA$$

This determines an equilibrium condition of constant ice thickness. A transfer of heat from water would tend to diminish the thickness, of course. When A = amount of sublimation during summer, H is end of summer ice thickness and Tt is freezing index in degree-seconds for following winter. Then rearrangement of equation (4) in form

$$H = \frac{KTt}{PLA} - \frac{A}{2} \qquad (7)$$

gives end of summer ice thickness as a function of summer sublimation and freezing index.

A graph of this function is given in Barnes, p. 113 (1960). Approximations based on limited climatological data available for this area and application of above equations indicate that approximately 75 ± 15 cm. of summer sublimation from ice sheet occurs. In evaluating this figure, the assumptions made above must be kept in mind. To maintain equilibrium an equal column of water must freeze, thereby both increasing salinity of adjacent water and supplying additional heat to the water from latent heat of freezing. The more dense water now sinks until it finds its equilibrium level. This process, repeated many times, is undoubtedly a source mechanism for some of concentrated lower waters of the lake and possibly also for some of entrapped heat of lower waters.

CHEMICAL CHARACTERISTICS

Table 3 illustrates the observed relations between the chemical and physical data. Examination of Figures 3, 5 and 6 shows that the major chemocline and thermoclines do not occur at the same point. The chemocline in all cases is seen to lie at 54 m.

The lake water is chemically stratified into two major strata. Minor layering is also suggested by chemical data (Table 3) and

TABLE 3.—Lake Vanda—Chemical Data in ppm for 1 January 1962.

Depth (m)	Li^+	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	$SO_4^=$	SiO_2	Density	pH	T° C	Conductivity (micromhos)
4.5	.....	6	2	17	4	<28	10	0	.....	1.000	7.5	0.75	130
6	.....	30	9	44	12	134	39	4	.....	1.000	7.4	3.5	555
9	.....	30	10	46	12	149	39	8	8	1.000	7.4	4.0	585
12	.....	35	11	54	13	164	41	8	.....	1.000	7.5	4.75	655
15	.....	51	15	83	22	260	49	16	.....	1.000	7.4	5.75	955
18	.....	99	29	181	47	564	66	12	.....	1.000	7.4	6.75	1990
21	.....	99	30	182	49	578	77	24	.....	1.000	7.4	7.0	1990
24	.....	100	30	182	48	576	78	24	.....	1.000	7.4	7.0	1990
27	.....	100	30	182	50	584	77	28	.....	1.000	7.4	7.5	1990
30	.....	100	30	182	50	586	78	24	.....	1.000	7.3	7.5	2025
33	.....	101	30	181	47	571	74	32	26	1.000	7.3	8.0	2025
36	.....	100	30	182	48	577	77	32	.....	1.000	7.3	8.0	2025
39	.....	100	30	182	50	576	77	44	.....	1.000	7.3	8.5	2025
42	∠1.0	127	35	264	70	827	79	36	.....	1.000	7.3	8.5	2700
45	∠1.0	150	40	345	95	1060	81	40	.....	1.000	7.3	8.5	3510
48	∠1.0	228	53	614	173	1910	84	80	26	1.000	7.2	10.5	5265
51	4	746	142	2730	915	8590	88	200	.....	1.005	6.9	12.0	22,220
54	14	1610	281	7150	2190	21,500	116	440	.....	1.024	6.7	15.0	45,455
57	20	2450	389	11,700	3780	36,600	139	770	.....	1.040	6.7	17.0	71,430
60	32	3750	515	16,700	6190	51,000	182	1880	110	1.067	6.7	22.0	100,000
66*	.....	6761	766	24,254	7684	75,870	126	770	.....	.....	6.1	22.0	.....

* December 1961 data—added for comparison.

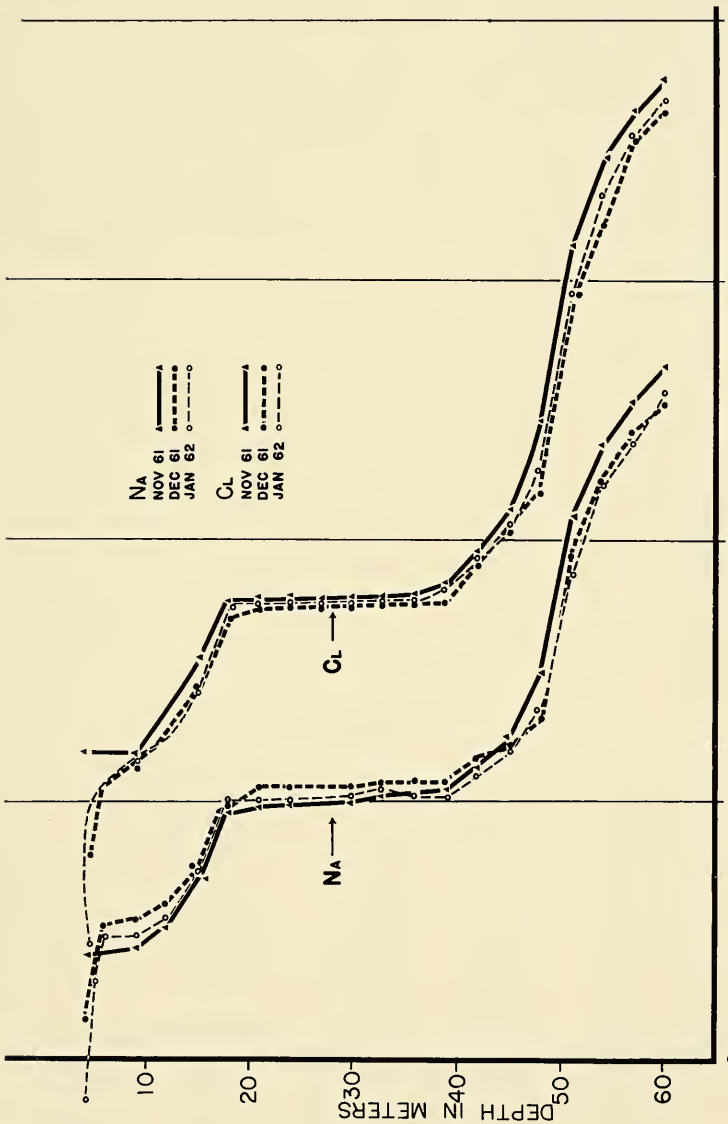

FIG. 5.—The distribution of Na^+ and Cl^- in Lake Vanda. Note that the chemocline lies at about 51m.

thermal profiles, but is difficult to prove. Maximal salinity of lower waters exceeds that of sea water by 2.6. Waters above 54 m. can be considered essentially fresh water types, although the Cl^- content is rather high. Several possible sources of these salts can be postulated; however, except for those discussed below, most can be eliminated for various reasons.

The principal dissolved salts in Lake Vanda are calcium, magnesium, and sodium chloride in descending order. Recorded pH varied from 8.3 at the surface to 6.3 at bottom. Within a solution of this pH range, bicarbonate (HCO_3^-) is the significant carbonate species in solution (CO_3^- was not detected) and the following reaction probably takes place under certain conditions and at certain times:

$$(HCO_3)_{aq}^- + Ca_{aq}^{++} \rightleftharpoons H_{aq}^+ + CaCO_3\,(\text{solid}) \downarrow \qquad (8)$$

X-ray diffraction studies of hexagonal crystals separated from bottom sediments of Lake Vanda clearly confirm the precipitation of calcitic carbonate. Sodium chloride and sodium sulfate are weakly indicated from diffraction patterns.

Other unidentified salts were also present. Although the HCO_3/Cl and SO_4/Cl ratios (ppm.) appromixate those of sea water in certain strata, the salinity of the lake waters and other elemental ratios (Ca/Mg, Na/K, etc.) do not conform to those of marine

TABLE 4.—Ratios by weight—Lake Vanda Hole 1—January 1, 1962.

Depth (m)	HCO_3/Cl	SO_4/Cl	K/Na	Ca+Mg/Na+K	Li/Na
4.5	0.35	0.00	0.32	2.52	.....
6	0.29	0.03	0.30	1.44	.....
9	0.26	0.053	0.32	1.48	.....
12	0.25	0.049	0.31	1.45	.....
15	0.19	0.062	0.29	1.59	.....
18	0.12	0.02	0.29	1.78	.....
21	0.13	0.04	0.30	1.79	.....
24	0.14	0.04	0.30	1.77	.....
27	0.13	0.048	0.300	1.784	.....
30	0.133	0.041	0.300	1.782	.....
33	0.130	0.056	0.270	1.618	.....
36	0.133	0.055	0.300	1.768	.....
39	0.134	0.076	0.300	1.783	0.00
42	0.096	0.044	0.276	2.062	0.00
45	0.076	0.038	0.267	2.316	0.0066
48	0.044	0.042	0.232	2.801	0.0044
51	0.010	0.023	0.190	4.105	0.0054
54	0.0053	0.021	0.175	4.939	0.0087
57	0.0039	0.022	0.159	5.453	0.0082
60	0.0038	0.039	0.137	5.367	0.0085

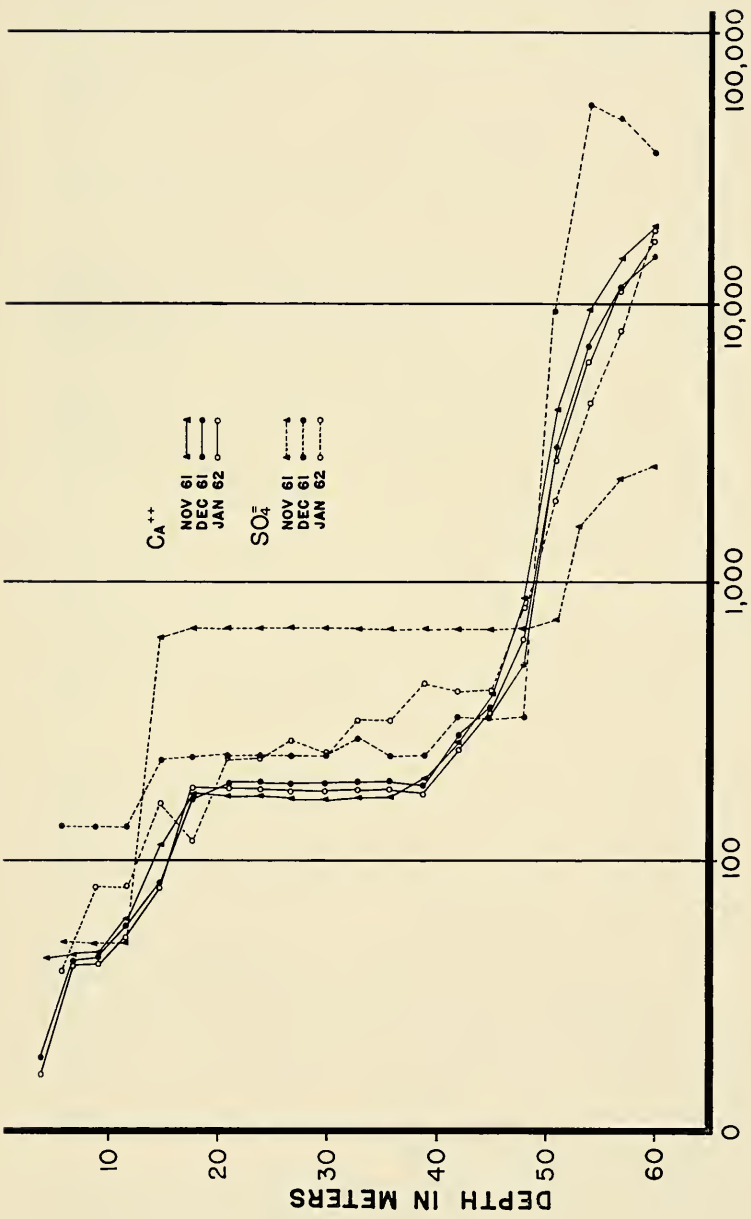

FIG. 6.—The distribution of Ca^{++} and $SO_4^{=}$ in Lake Vanda. Note the marked seasonal fluctuation in $SO_4^{=}$.

waters (Table 4). Marked differences are also noted with respect to other known salt water constituents. $Ca^{=}$ and Cl^{-} make up approximately 86% of total dissolved salts of the lake; if Mg^{2+} and Na^{+} are added, then 98.8% of dissolved constituents are accounted for. The similarity between composition of these waters and those identified from a nearby pond (Tedrow, *et al.*, 1963) is striking. Within this area the same processes appear to be operative in both lakes. The lower waters (in fact, most of waters) of Lake Vanda could quite properly be regarded as a brine of calcium-magnesium chloride.

The extremely high Cl^{-} content of lower waters and, in fact, most of upper waters as well, is somewhat enigmatic. Assuming an influx of thermal waters now or at some time in the recent past, then the high Cl^{-} values are partially explained. Additionally, leaching and subsequent concentration by sublimation and evaporation of Cl^{-} from Cl^{-} rich soils in the area (Tedrow, *et al.*, 1963) may also contribute heavily to Cl^{-} content in the lake. Rocks in vicinity of the lake are primarily igneous and metamorphic, both of which are minor sources of Cl^{-}.

Silica appears anomolously high in lower waters. However, if we consider that similarly high values have been reported for other saline lakes in the area (Angino, Armitage and Tash, 1962b) and if we consider the possibility of chemical solution of rock walls of the lake by acidic bottom waters over long periods of time, then we may consider that such high SiO_2 values (162 ppm.) are in reality "normal" for saline lakes of this type.

Lithium is normally quite low in sea water (0.1 ppm., Mason, 1958) and in most fresh water lakes and streams. The most logical source of the high Li^{+} content in Lake Vanda would appear to be volcanic hot spring. The Li/Na ratios (Table 4) also argue strongly for this origin (White, 1957).

Nitrate and iron were not detected and phosphate, nitrite and NH_3 were detected only in trace amounts and will be discussed further in a later paper on trace elements of Antarctic Saline Lakes. A strong odor of H_2S was noted in all samples brought to the surface from below 61 m.

The roles of Na^{+}, K^{+}, HCO_3^{-}, and $SO_4^{=}$ are discussed in more detail under section on Sources of Salts.

The dissociation constant of H_2S in fresh water at 25°C is 5.7×10^{8}. According to Hutchinson (1957, p. 759) water subjected to a pressure of 1 atm. of H_2S will have a $pH = 4$. The addition of base substances will cause a rise in pH. Thus the pH of the

system is a function of continued supply of the weak acid of H_2S to the buffering capacity of system. Possibly this mechanism may be applicable here as suggested by pH data (see various tables). The presence of a weak solution of H_2SO_4 formed from $SO_4^=$ and H^+ present is another possible cause of low pH values measured in bottom waters.

SOURCES OF SALTS

Some chemical weathering is operative in this area, according to work of Tedrow, *et al.* (1953). Jensen (1916) reported high levels of Ca^{++}, K^+, Mg^{++}, and Cl^- in Antarctic soils. Leaching of these salts from soils surrounding Lake Vanda and their ultimate deposition in the lake may account for part of the dissolved salts present. Markov (1956) has described the migration of salts in various rocks and minerals in Mirny area and Glazovoskaia (1958) and Angino, Armitage and Tash (1962b) report presence of carbonate deposited as white coating on bare rock surfaces. McCraw (1960) has mentioned layers of $CaCO_3$, in soils of Antarctica. More recently Johannesson and Gibson (1962) report the formation of NO_3^- and IO_4^- deposits in soils of Ross Dependency. Leaching of soils would supply these salts to waters of Lake Vanda. The absence of NO_3^- and the trace amounts of NO_2 and NH_3 in Vanda waters may result from the activity of algae in the upper 33 m. (Armitage and House, 1962; Wilson and Wellman, 1962). IO_4^- was not present in water samples collected from Lake Vanda in November and December; it was present only at 51 m. (0.63 ppm.) and 54 m. (0.05 ppm.) on 8 January. The presence of IO_4^- thus coincides with the upper edge of the chemocline and with the season when melt water enters the lake. It seems likely that the iodate was carried to its location in the lake by melt water more dense than the mixolimnion of Lake Vanda. Abundant evidence exists, therefore, for extensive chemical alteration of rocks and minerals under climatic conditions prevailing in Antarctica. Recently Keller, *et al.* (1963) have shown definitely the conversion of normally stable minerals into readily soluble forms by glacial abrasion and subsequent incorporation into glacial melt water. Thus, subsequent to their release from parent rock the Na^+, K^+, Ca^{++} and Mg^{++} will be in a potentially mobile stage. That this is true is seen by reference to work of Ball and Nichols (1957), Tedrow, *et al.* (1963) and Hamilton, Frost and Hayes (1962) who report large patches of a white powdery efflorescence on glacial, beach, and other deposits in the general area. They attribute these coatings to evaporation of windblown sea spray. Is it

not possible that some of these salts may be weathered products carried upward by capillary action and deposited at surface of rock material by evaporation of water under the arid antarctic climate? X-ray diffraction studies of these powders give typical pattern for NaCl and Na_2SO_4 (Ball and Nichols, 1960) and $CaCl_2$ (Tedrow, *et al.*, 1963) and $CaSO_4$.

The presence of inconspicuous salt crusts covering much peripheral area near Lake Vanda and their presence in numerous small depressions throughout the area indicate that migration (leaching) of salts downgrade by soluble salt transfer does occur. Soil conditions in basins, swales, and depressions in the vicinity (Tedrow, *et al.*, 1963) strongly support the salt migration hypothesis. Transport to and ultimate deposition of these salts in Lake Vanda both by surficial and ground water transport, is undoubtedly a major contributor to the dissolved salt content of the lake (Gibson, 1962, p. 372).

Leaching of these salts with subsequent deposition of salt-laden waters of the enclosed basin in Lake Vanda provides a likely source of part of HCO_3^-, $SO_4^=$, and part of Cl^-. Atmospheric CO_2 as well as recycled (windblown) Cl^- also are possible sources, though probably minor ones in this area. A marine origin (relict sea water) for the monimolimnion of Lake Vanda is not considered likely. Ocean spray blown inland from McMurdo Sound, 30 kilometers to the east, and open 2-2.5 months of the year under present climatic conditions is possibly another minor source of salts, especially sodium chloride.

The rather high Mg^{++} concentration can be reasonably explained by the proximity of dolomitic marbles. This area, although an enclosed basin, is drained by moderate-sized intermittent melt water streams draining west from Wilson Piedmont Glacier and into the valley from alpine glaciers on valley walls. Some of these streams cross a series of vertical marble beds, part of the bedrock floor of the Valley (McKelvey and Webb, 1962). These streams flow for only about two months or less of the year. Assuming a longtime concentration process, the occurrence of these marble beds could supply a part of Mg^{++} and Ca^{++} to the lake. The low Ca/Mg ratios (calculated on equivalent basis) of waters also argues strongly for presence of dolomite in drainage area (Hem, 1959).

Normal evaporative processes acting in an arid environment would also bring about an increase in Mg^{++} content, owing to both the relatively high solubility of magnesium salts and to the increased

solubility of these same salts in presence of waters with a high sodium content. Briefly, Mg^{++}, once in solution, has a strong tendency to remain in solution. The high content of K^{+} and SO_4 is puzzling, especially the large temporal variation of the latter. This change in SO_4 appears to be a real phenomenon inasmuch as the data, expressed as equivalent ppm., check out. Reduction by bacterial action is also feasible. The possibility also exists that the thermal springs postulated to be entering the lake and normally charged in SO_2 or SO_3 contribute indirectly to the high SO_4 content. Normal evaporative and weathering processes and subsequent concentration by freezing mechanisms reasonably account for the potassium content.

Additional support for thermal inflow is the presence of radio-

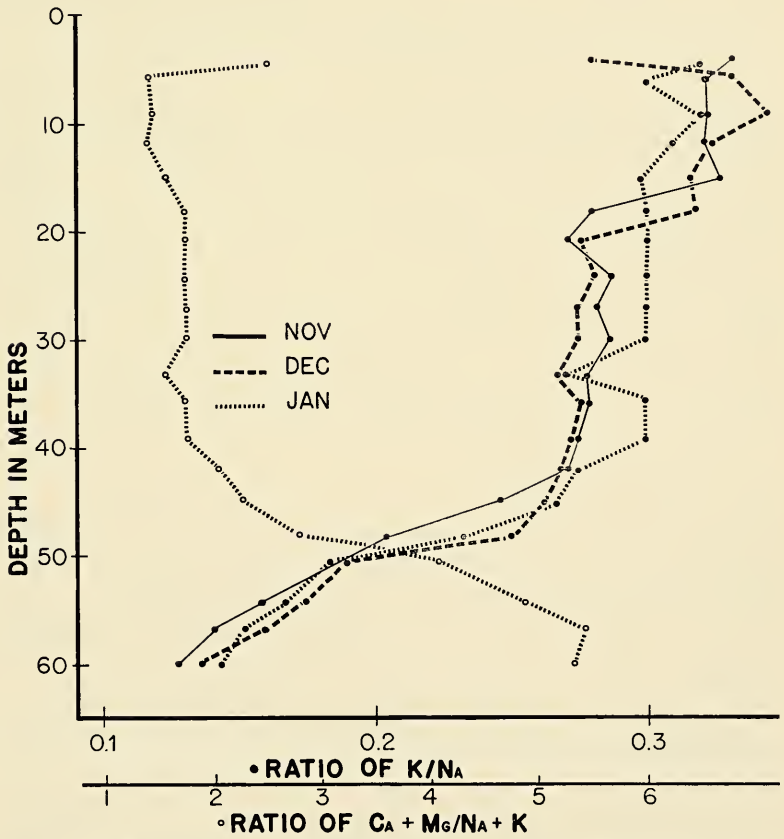

FIG. 7.—The distribution of the ratios of K/Na and Ca + Mg/Na + K in Lake Vanda.

activity in the lower waters of Vanda. The nature of the radioactivity is currently being analyzed and will be reported in detail in a subsequent paper.

The criteria of White (1957) may be used to differentiate water of different sources. The Li/Na and K/Na fall completely within the range given for volcanic hot springs (Table 4); HCO_3/Cl and SO_4/Cl are included in the range of both volcanic hot springs and brines. The $Ca + Mg/Na + K$ falls completely within the range for brines.

The curve of K/Na ratios (Figure 7) indicates seasonal mixing of waters in the upper 18 m. Below the chemocline the curve shifts strongly to the range characteristic of volcanic hot springs. Such a shift would be expected if thermal waters are now entering the lower waters of Lake Vanda. The high Li values below the chemocline additionally support an influx of thermal waters.

SUMMARY AND CONCLUSIONS

The saline waters of Lake Vanda have a complex origin. The Li/Na, K/Na, HCO_3/Cl and SO_4/Cl support an origin from thermal springs. The $Ca + Mg/Na + K$, HCO_3/Cl and SO_4/Cl indicate brine formation by concentration mechanisms. Thus the measured salinities appear to have been brought about by a combination of the introduction of mineralized waters and the concentration of these and other waters flowing into the lake by a sublimation-freezing mechanism. Old shore lines 55 m. above present lake level further support the concept that concentration has had an important role in determining salinity. However, with present data, it is not possible to define the specific contribution of each source to the salt contents of the lake.

The waters of the lake, especially those of the lower 10 m., may be regarded as a calcium-magnesium chloride brine. Abundant evidence exists for extensive chemical alteration of rocks and minerals under the prevailing climatic conditions of Antarctica which provides a source of Na^+, K^+, Ca^{++} and Mg^{++}. Chloride is also high in antarctic soils. Relict sea water does not seem to be present. Windblown salts may make a minor contribution to the lake.

A thermal dome appears to be present near the center of the lake between Holes 4 and 13. This dome appears explicable on the basis of an influx of thermal waters. The isothermal patterns are not readily explained if solar heating is postulated. Seasonal changes in temperature also support an upward movement of heat.

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Stelastellara parvula, a New Genus of Unknown Affinity from the American Carboniferous

BY

ROBERT W. BAXTER

ABSTRACT: *Stelastellara parvula* is described as a new genus of American coal ball plants on the basis of 12 specimens from the Desmoinesian series of Kansas and Iowa. The specimens consist of small (under 4 mm. diameter) unbranched axes with stellate steles of 5 to 10 exarch primary bundles. The secondary xylem and periderm follow and exaggerate the star-shaped stelar outline in the most mature specimens. The pitting is reticulate bordered. The cortex consists of a homogeneous collenchyma with greatly thickened tangential walls which give the tissue a "speckled" appearance. The affinites of the genus are unknown, but it is suggested that it may be a root or rhizome belonging in the Coenopteridales. Striking similarities to certain Devonian plants are also noted.

INTRODUCTION

While the upper Carboniferous flora, as represented by the plant remains preserved in American coal balls, has become increasingly well known over the past few decades, plant organs which defy all attempts to assign them to recognized groups still occur with frustrating frequency. The present account is concerned with such a case. The material to be described cannot only not be correlated with any presently known class but it cannot be stated with assurance as to exactly what part of the plant body is represented other than it is a plant axis, either root or stem.

The descriptions are based on 12 specimens found in 8 different coal balls. Two specimens (E1 and E2) were found in a coal ball from the Des Moines Series of Iowa, all of the others came from coal balls of the Fleming coal of Kansas. In four instances two specimens were found in the same coal ball in all other cases only a single specimen was found per coal ball.

In the cases where the two specimens were present in the same coal ball, they were usually closely associated with each other but no actual physical connection between them was ever observed.

The specimens consist of long, slender axes, essentially straight or only slightly curved, which in several cases extended as much as 10-14 cm. through the coal ball matrix without showing any nodes, leaves, or branching. In two specimens (E1 and G, both of which were followed by sections for over 8 cm.) one or two transverse peels showed strands of vascular tissue departing from protoxylem points of some primary bundles and running out through the cortex at right angles to the main axis (fig. 5). These structures looked similar to those frequently found in adventitious or branch roots but no such roots, if they existed, were ever sufficiently preserved to be recognized.

The axes are very small, never over 3-4 mm. in their greatest diameter, and in transverse section show a circular to lenticular form. The main characteristics are a very distinctive cortical tissue, which will be described in detail below, the exarch primary bundles usually loosely arranged in a circle or ellipse around a distinct pith region and in the older specimens an unusual development of secondary xylem and periderm. Because of the many distinctive features it has been felt necessary to establish the new genus, *Stelastellara*, the generic and specific diagnosis of which will be given later in the paper.

GENERAL DESCRIPTION

The Pith—While the primary bundles are distinctively exarch in their development there is never any tendency for them to fuse in their centripetal growth so that a pith area is present in even the smallest specimens. As the stems mature there seems to be a trend towards enlargement of the pith through a spreading apart of the primary bundles. Thus the older stems (as evidenced by the presence of secondary tissues) usually have a larger pith than those with just primary growth. One exception to this condition is shown by specimen G (fig. 13) which, however, also differs from the other 11 specimens in several other ways as will be brought out later in the detailed descriptions of the individual specimens.

The pith tissue is usually so poorly preserved as to obscure cellular details. It appears, however, to consist of thin walled parenchyma, intermixed with elongate "resin" or "mucilage" canals which are typically filled with an opaque, black substance. The central portion of the pith in the older stems often seems to have disinte-

grated leaving a hollow area. In stems with well developed secondary xylem there also seems to have been a tendency for the pith to be crushed by the flattening of the stele through the tangential expansion of the secondary tissue between the radiating arms of the primary bundles (fig. 1).

The Primary Xylem—The primary xylem consists of from 5 to 10 exarch strands arranged in a circle or ellipse. Of the twelve specimens observed 4 have 5 primary strands, 4 have 6 primary strands, 1 has 7 primary strands, and 3 have 10 primary strands. There does not seem to be any correlation between number of primary strands and the presence of secondary xylem, as secondary growth was found to be present about as frequently in the 5 bundle forms as in the 10 bundle specimens.

In transverse section of the axis the primary bundles are typically tear-drop shaped with their radial measurement about 4 times their greatest tangential width (figs. 7, 9, and 10). The protoxylem is situated in the outer acuminate tips with the larger metaxylem cells towards the center so that the direction of development is clearly exarch. Radial-longitudinal sections show the protoxylem tracheids to average 18μ in diameter with annular secondary thickenings (fig. 19). As one moves towards the axis center through the metaxylem tracheids, transitional pitting is found ranging from scalariform (fig. 20) to reticulate bordered pits (figs. 21 and 22). The bordered pits which are found in all of the later metaxylem tracheids and on the radial walls of the secondary xylem tracheids are alternately arranged in as many as 5 rows in some of the larger metaxylem cells. The pit apertures are often horizontal slits (fig. 22) but may also frequently be oblique and present cross-shaped patterns when opposing apertures are both visible.

Secondary Xylem—Secondary xylem is present in 7 of the 12 specimens. It varies from 2-3 rows in thickness as shown in specimen A (fig. 1) to 9-11 cells in thickness as illustrated in specimen D1 (fig. 4). The tracheids are rectangular in transverse section with average dimensions of 20μ by 40μ with the radial width being the greater (figs. 6 and 7). The pitting is primarily restricted to the radial walls and consists of alternately arranged bordered pits (fig. 22). There are no xylem rays. One of the distinctive attributes of the secondary xylem is that the fascicular portion associated with the primary bundles was usually produced only opposite the metaxylem and rarely extended around the protoxylem points (figs. 1, 6, and 7).

Since the primary bundles are radially elongated this produced a growth pattern in which most of the fascicular secondary xylem developed in a tangential rather than radial direction as observed in transverse sections of the axis (figs. 1, 2, 4, 6, and 7). Radially aligned interfascicular secondary xylem apparently originated at the same time as the fascicular tissue as it usually shows the same thickness where its growth has not been constricted by the encroachment of the tangential fascicular wood. Ultimately, the growth of the interfascicular xylem would seem to have been completely pinched off by the coming together of the secondary xylem developing tangentially between adjacent primary strands (figs. 1, 4, and 6). The spacing between adjacent primary bundles is not always constant so that an individual stele may have considerable interfascicular xylem between some primary strands and practically none between others (fig. 4).

Cambium and Phloem—Not a great deal can be said of these tissues. The presence of a vascular cambium is indicated by the well developed secondary xylem. The crushing and generally poor preservation of the tissue however prevents any accurate observations as to the cellular details. While poor preservation is also characteristic of the phloem the gross aspects of the tissue are easy to observe as it is clearly limited on the inner side by the xylem and crushed cambium and on the outer by a well developed periderm or distinctive cortex (figs. 1, 6, 7, 9, 10, and 13). Interspersed among the vertically elongate parenchyma (sieve?) cells are numerous "resin" or "mucilage" canals filled with a black, opaque material similar to those found in the pith (figs. 7 and 14).

The Periderm—This tissue was present in 9 out of 12 specimens examined. All of the 3 specimens lacking periderm (figs. 9, 11, 12, and 18) also lacked secondary xylem and were generally smaller than the others so that absence of the tissue in these cases would appear to be due to their immaturity.

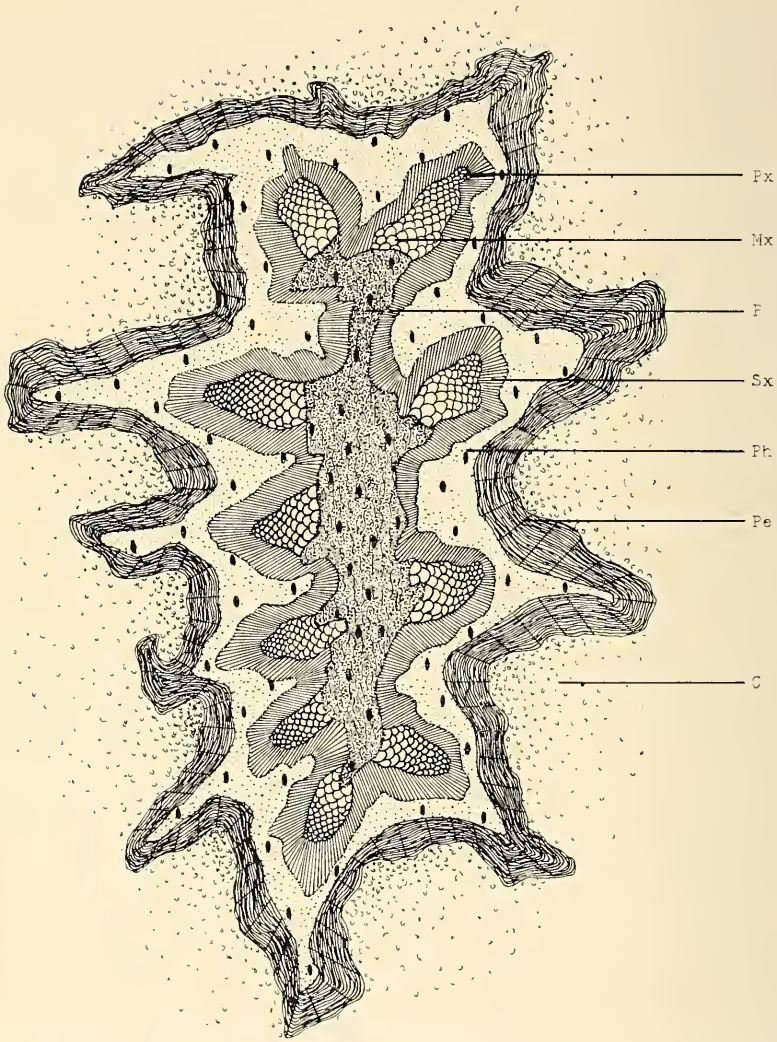
Of the remaining specimens, the periderm was present in 2 with only primary xylem (figs. 10 and 13) while all of the 7 specimens having secondary xylem also possessed periderm. As shown in figures 10 and 13, the periderm is clearly endogenous apparently arising in the outer primary phloem or pericycle. As in the phloem, this tissue is usually so crushed and poorly preserved that cellular details are difficult to observe. However specimen E1 (fig. 5) produced some peels with sufficient preservation to show cells of thin walled parenchyma in regular, radial rows indicating their secondary origin from a lateral meristematic tissue.

The most striking feature of the periderm observed in some specimens (and probably potentially present in all) is the tendency to produce radially extended lobes opposite the primary bundles. That this is more than just a simple following of the star-shaped outline of the stele can be seen in specimen A (fig. 1) where the periderm lobes opposite the protoxylem extend outwards completely through the outer edge of the cortex. With the eventual sloughing off of the tissues outside the periderm (as has sometimes been seen to occur) this produces a deeply fluted axis in which the periderm forms the outermost layer.

The Cortex—This is a homogeneous tissue consisting of rectangular cells elongated parallel to the axis and having an average length of 180μ with nearly transverse end walls (fig. 15). In transverse sections of the axis the cells measure an average of 20μ x 40μ with the radial walls always being approximately twice the length of the tangential walls. The radial walls are consistantly thin, seldom exceeding 3μ in width, whereas the tangential walls are conspicuously thickened (16μ-20μ), forming lenticular to diamond shaped strands (fig. 16). Superficially the tissue is similar in appearance to the collenchyma of those modern plants having tangentially thickened collenchyma, such as *Sambucus*, *Eupatorium*, etc., although here the wall thickening is more completely confined to the center of the tangential walls than in any known extant plant. Median-longitudinal sections of the axis tend to cut through only the tangential walls of the cortical cells so that the tissue in this aspect consists of uniformly thickened walls, the transverse end walls being of equal thickness to the tangential (fig. 15).

The thin radial walls are seldom preserved so that the cortex usually presents a distinctive, characteristic view in transverse sections of the axis appearing as a mass of evenly spaced lenticular dots (figs. 2, 6, 13, and 16). This type of preservation (or lack of it) is consistant through all of the specimens observed and is so distinctive that it alone usually provides a basis for recognizing the genus.

The exterior of the cortex frequently shows irregular lobes and furrows (figs. 10, 12, and 18) while none of the 12 specimens in either transverse or extensive longitudinal sections exhibited any tissue identifiable as epidermis. It seems reasonable to assume that (as in many roots) the epidermis lacks cuticle and is little differentiated from the adjoining cortical cells or that it was sloughed off at an early stage of development.



TEXT FIG. I. *Stelastellara parvula*—Diagrammatic drawing of specimen A. Also see photographic illustration of same section in Plate I, fig. 1. P, pith; Px, protoxylem; Mx, metaxylem; Sx, secondary xylem; Ph, phloem; Pe, periderm; C, cortex.

DESCRIPTION OF INDIVIDUAL SPECIMENS:

Specimen A—This specimen is illustrated in text figure I and in figures 1 and 6. It, like most of the other specimens described, was found in a coal ball (M1263) collected from the well known Pittsburg-Midway Mine near Hallowell, Kansas, in which abundant coal balls occur in the Fleming Coal, Cherokee Group of the Desmoinesian Series.

The first cut exposed a transverse section of the axis and subsequent cuts and peel thin sections showed the axis to run, in an almost straight line through the entire coal ball, for 9.4 cm. Its structure as shown in figure 1 remained the same for all of this considerable length with no evidence of lateral organs such as leaves, branches, or adventitious roots.

The transverse outline of the axis is oblong to lenticular and measures 3.0 mm. x 2.2 mm. The pith region measures .18 mm. x 1.4 mm., its extreme bilateral symmetry possibly resulting from the pressures exerted on it due to the tangential expansion of the secondary xylem on the sides of the primary bundles. The stele, including secondary xylem, measures 1.1 mm. x 2.2 mm. as seen in transverse section and consists of 10 primary exarch strands which average .54 mm. x .12 mm. so that their radial dimension is approximately 4 times their tangential width. The secondary xylem ranges from 2-3 cells in thickness. The lobing of the periderm is the most pronounced of all the specimens, most of the lobes extending outwards completely through the cortex.

This specimen, like most of the others with secondary thickening, exhibits an eliptical-oblong shape in transverse section with all of the internal tissue conforming to the pattern. This appears to be a natural configuration and not due to crushing as evidenced by the following facts. Any external pressures sufficient to have compressed the stele to its extreme asymmetry would have been expected to have also compressed the projecting periderm lobes and fragile cortex. This, however, is not the case. Also, completely undistorted specimens of *Myeloxylen* and *Psaronius* roots were associated with the *Stelastellara* axis on the sides on which compression would have had to occur.

Specimens B1 and B2—Both of these were found in coal ball M1267 from the same Kansas locality as specimen A. Specimen B1 (figs. 2 and 7) has 5 primary exarch bundles surrounded by well developed secondary xylem and a very thin, inconspicuous periderm.

The 5 strands of primary xylem are just one-half as many as were found in specimen A. Possibly because of this, the secondary xylem expanding tangentially from the sides of the metaxylem had more room for growth and less tendency to crush and distort the pith and symmetry of the stele. At least, as shown in figure 2 these are much more radially symmetrical than in the previous specimen. Figure 7, showing enlarged detail of one of the arms of the star-shaped stele, illustrates the character of the primary and secondary xylem

as well as the speckled cortex. This specimen followed a slightly sinuous path through the coal ball for 6 cm. without any evidence of change, or giving off of lateral appendages. Its transverse dimensions as shown in figure 2 are 2 mm. x 4 mm.

Specimen B2 (figs. 11 and 12) has a small hexarch stele 1.2 mm. in diameter. The six exarch strands are more compactly grouped than in most the other specimens, forming a quite regular 6-pointed star with only a small central pith. No secondary tissues are present. The cortex presents the usual speckled appearance due to the evenly spaced tangential wall thickenings of the collenchyma-like cells. As shown in figure 11, the axis was first cut as an oblique-transverse section. This was later corrected to a true transverse section which measures 2.6 mm. in diameter (fig. 12). The outer cortex is well preserved and shows a ridged and furrowed surface with no clearly defined epidermis.

Specimen C—As shown in figure 3 this axis measures 2.5 mm. x 1.8 mm. Since little is preserved exterior to the periderm, this is essentially the measurement of the stele itself. The stele is pentarch with the 5 primary xylem bundles being arranged in a roughly rectangular shape. The primary strands have been joined by development of 4-5 layers of secondary xylem with fairly extensive interfascicular areas. The cortex is not preserved but occasional fragments of periderm show that this tissue was present. The specimen was found in coal ball M1242F from the Kansas Fleming coal.

Specimens D1 and D2—These 2 axes were found in coal ball M14A also from the Kansas Fleming coal. Specimen D1 (fig. 4) had been badly macerated prior to preservation so that its entire structure had to be reconstructed from various sections. The primary bundles visible in the illustration are just 4 of the 10 characteristic of the complete stele. Typical secondary xylem, periderm, and cortex can also be seen in the better preserved areas. While there is evidence of greater development of interfascicular secondary xylem this specimen seems most comparable to specimen A.

Specimen D2 (fig. 10) is an axis of elliptical shape in transverse section measuring 2.6 mm. across its narrower width. The stele consists of 6 irregularly spaced exarch bundles enclosing a loosely defined pith and surrounded by phloem and a well developed periderm. No secondary xylem is present. The cortex is extensive, well preserved, and shows the usual distinctive tangential wall thickenings. The outer surface of the cortex is lobed as in specimen B2.

It is possibly worth noting that in both cases where 2 axes were associated in the same coal ball (specimens B1, B2 and D1, D2) that one of the axes had well developed secondary xylem and the other only primary. This suggests that possibly one might be the more mature main axis and the other a younger branch. While this may be true, no connection between any 2 axes has ever been found although some have been followed for up to 10 cm.

Specimens E1 and E2—These specimens were found in coal ball 728 collected at the Patik Coal Mine near Oskaloosa, Iowa. As in the previous examples of paired axes in a single coal ball, one is characterized by considerable secondary growth while the other shows only primary tissues. Specimen E1 (fig. 5) illustrates the more mature form. While a portion of the stele is poorly preserved it is evident that there were 6 primary xylem strands surrounding a fairly large pith. Secondary xylem is well developed and is mainly fascicular with the portions between the star-shaped arms being much constricted. The periderm is unusually well preserved and shows a definite radial arrangement of thin walled cells. The most unusual feature of this specimen is that, in the area of the axis illustrated, a vascular trace can be seen passing from one of the protoxylem points, horizontally out through the cortex. This looks similar to the structure which might be expected in an adventitious or branch root and is one of the few suggestions as to types of lateral organs to be found in *Stelastellara.*

Specimen E2 (fig. 9) has 7 primary xylem bundles arranged in an irregular star-shaped cluster enclosing a small pith. In the section illustrated there is a slight gap in the cortex making it appear that an 8th bundle might have been present. However other sections show that this was not the case and that 7 was the true number of primary bundles. No secondary xylem or periderm are present. The specimen has an average transverse measurement of 2.2 mm. x 1.5 mm.

Specimens F1 and F2—These 2 specimens from a Kansas Fleming coal ball M1082 are rather poorly preserved. Unlike the paired specimens previously described both of these axes have secondary xylem and periderm. Specimen F1 (fig. 8) has 5 primary xylem bundles each having 2-3 layers of fascicular secondary xylem. Interfascicular secondary xylem is poorly developed and there seems to have been some compression of tissues between the primary bundles. The specimen is one of the smallest showing secondary development, measuring 2.2 mm. x 1.3 mm.

Specimen F2 (Fig. 17) also has 5 primary xylem bundles surrounded by a thin layer of fascicular and interfascicular secondary xylem. Neither pith nor phloem tissues are preserved but the periderm is distinct as an irregular ring of dark compressed cells with the 5 angular lobes (as seen in the transverse section of the axis) marking the position of the 5 primary xylem bundles. The cortex is the best preserved here of any of the specimens and shows the contrast between the thin radial walls and the extremely thickened tangential walls (fig. 16). The specimen is slightly larger than F1, its transverse section measuring 2.5 mm. x 1.6 mm.

Specimen G—This specimen (fig. 13) was found in coal ball M29 from the Kansas Fleming coal. It extended in a straight line through the coal ball for over 14 cm. with no change in its size or structure and no evidence of any lateral appendages other than traces to a few possible adventitious or branch roots. The stele consists of 10 exarch primary bundles arranged in a nearly perfect circle around a hollow pith area. The primary xylem bundles are broader in their tangential dimension than in any of the other specimens. Here the ratio between the radial and tangential width of the primary xylem is less than 2 to 1 while in all of the other specimens it averaged 4 to 1. No secondary xylem is present, although the phloem tissue is encircled by a well developed periderm. The cortex shows the typical speckled pattern and is nearly circular in outline with a diameter of 3.2 mm.

Specimen H—This small axis measuring 2.2 mm. x 1.5 mm. in transverse section (fig. 18) was found in Kansas Fleming coal ball M1048. It has 6 primary xylem bundles arranged in an irregular star around a central pith. It lacks secondary xylem and periderm. Its outer cortex shows a lobed-furrowed surface similar to specimen D2 with which it is probably most comparable.

DISCUSSION

It seems most probable, from the present evidence, that *Stelastellara* is either a root or a rhizome of some unknown plant. The root like characters are fairly numerous and include the following: (1) exarch primary xylem; (2) endogenous origin of periderm; (3) an apparent lack of nodes and internodes, *i. e.*—no evidence of leaves or leaf traces; (4) delayed development of cambium and secondary tissues opposite the protoxylem points. In the roots of *Pinus,* for example, the cambial activity opposite the protoxylem points does

not begin until long after that producing the secondary tissues opposite the metaxylem. In *Stelastellara* it seems likely that the cambium developed over the protoxylem points only in the oldest of specimens. (5) Lack of a clearly defined epidermis and cuticle. A number of the above characters are, of course, also to be found in paleozoic stems such as *Sphenophyllum.* However, *Sphenophyllum* still is clearly a stem with its numerous nodes, whorled leaves, and stem-like cortex.

The fact that one of the specimens of *Stelastellara* was followed for 14 cm. and several other for nearly 10 cm. without finding any nodal structures seems one of the strongest points for its interpretation as a root rather than a stem although it is also recognized that a number of the living ferns have scrambling rhizomes in which the internodes may average 20 cm. or more between nodes.

The cortical collenchyma of *Stelastellara*, the nearly straight axis, and paucity of branch or adventitious roots are features which may also be used to support the rhizome concept. In the absence of conclusive proof it is probably best to leave the question open, recognizing for the time being that the interpretation as a root seems at present to have possibly a little more evidence in its favor than as a stem (rhizome).

The problem of the systematic position of *Stelastellara* is even more difficult than determining its position in the plant body. The lack of any knowledge as to leaves, branches, or fructifications and the fact that we are possibly dealing here with only the root of the plant severely limits critical comparisons. However if we assume (on the basis of the evidence) that the organ *is* a root we still find it to be completely unlike any roots so far associated with the known groups of Pennsylvanian plants. *Psaronius* has roots with similar star-shaped clusters of exarch bundles but, of course, never has secondary xylem and has a distinctive aerenchyma cortical tissue and scalariform pitting. The reticulate bordered pitting in *Stelastellara* is comparable to that in the Pteridospermae, some members of the Coenopteridales (Baxter, 1952, fig. 5), and the Sphenophyllales. However the roots of the genera of these orders are well known in most cases and other than the general similarity of tracheid pitting have totally different anatomical features than those found in *Stelastellara.* On the other hand the presence of bordered pitting may be used in a negative sense to rule out affinity with orders known to lack this feature such as the Lepidodendrales and Marattiales.

Of all of the known orders of Carboniferous coal ball plants, the Coenopteridales with their great diversity of form and their frequent rhizomatous habit possibly offer the most likely area of affinity with *Stelastellara*. The complex star-shaped stele of *Asterochlaena* presents a general similarity in gross appearance to that of *Stelastellara* as shown in figure 1. The differences between the genera however, *e. g.*—the "peripheral loops" of *Asterochlaena,* its numerous leaf traces and lack of secondary tissues, are so numerous and basic that no close comparison is possible.

While comparisons with Carboniferous plants are few and difficult, a number of striking similarities occur between *Stelastellara* and certain Devonian genera. *Actinopodium nathorstii* (Hoeg, 1942) is very like our axis in size and general appearance as can be noted by a comparison of his figs. 1 and 2, plate LVIII with our figs. 3, 8 and 17. The points of similarity described for *Actinopodium* are lack of a differentiated epidermis, phloem with "dark lumps" (resin canals?), star shaped stele with "secondary" xylem and metaxylem with multiseriate bordered pits. Differences are that *Actinopodium* has mesarch protoxylem, gives off frequent cylindrical mesarch bundles and has a cortex of rounded cells with intercellular spaces at the corners.

The upper Devonian genus, *Siderella scotti* (Read, 1936) can also be compared to *Stelastellara* in its star shaped stele and small size. The rather definite "peripheral loops" of the former along with the production of small vascular traces to aphlebiae and large phyllophore traces seems however to indicate definite coenopterid affinities and are not matched by any equivalent structures in *Stelastellara.*

While *Stelastellara* can clearly not be assigned to either of the above Devonian genera, the presence of star shaped steles with primitive secondary xylem, *e. g.* lack of xylem rays, seems to be a frequent feature of many Devonian plants. As the author (Baxter, 1949) stated years ago in connection with the primitive pteridosperm stem, *Microspermopteris,* "at least a part of the undergrowth of Carboniferous times may have occupied a position comparable to that of the living 'fern allies' in that both present a retention of characters primitive for their time so that the excellent fossil record of the Pennsylvanian coal beds may yet provide the missing links from earlier eras just as those primitive living genera (*Lycopodium, Equisetum* and *Psilotum*) have done in part for the present day flora."

As Sahni (1948) stated in his often quoted remark about the Jurassic Pentoxyleae, we have here a plant which seems to "defy classification" and create more problems than it solves. The fact that *Stelastellara* seems unassignable to any of the known coal ball plants and is relatively rare among them also suggests the possibility that it may represent a transported fragment from a coexistent upland flora. Cridland and Morris (1963) point out that the occasional occurrence in otherwise typical Pennsylvanian compression fossils of such genera as *Walchia, Taeniopteris,* and *Dichophyllum* may be explained by assuming that they were a part of an upland flora near enough to the coal swamp vegetation to have occasional fragments washed down into it. It at least seems possible that the same circumstances could have now and then introduced foreign elements into the presumed swampy coastal areas of coal ball formation.

Whether *Stelastellara* does represent transported fragments from upland floras or is merely a portion of one of the probably numerous smaller elements of the coal swamp vegetation which still await discovery, its many unique characters seem to amply justify its recognition as a new genus for which the generic name *Stelastellara* is proposed as descriptive of its star shaped stele while the specific name *parvula* refers to its very small size.

Generic Diagnosis—Slender (under 1 cm.) axes unbranched and apparently lacking nodes and internodes. Stele consisting of a star-shaped cluster of exarch primary xylem strands surrounding a parenchymatous pith which sometimes becomes hollow. Secondary xylem, when present, produced in tangential rows opposite metaxylem of primary bundles and in radial rows in interfascicular areas between primary bundles. No secondary xylem usually present opposite protoxylem points. Pitting of metaxylem and secondary xylem of alternately arranged bordered pits.

Specific Diagnosis—Small root or rhizome less than 5 mm. in diameter. Pith hollow or consisting of rectangular parenchyma intermixed with vertically elongated "resin" or "mucilage" canals with black, opaque contents. Five to ten tear-drop shaped, exarch primary xylem bundles arranged in a star-shaped cluster around the pith. Phloem consisting of mixed elongate parenchyma and "resin" canals similar to those in the pith. Periderm, when present, producing radially-elongate lobes opposite primary bundles, the lobes sometimes extending completely through the cortex. Cortex consisting

of a homogeneous collenchyma in which usually only the greatly thickened, lenticular, tangential walls are preserved so that transverse sections of the tissue looks like a mass of evenly spaced dots. Lacking differentiated epidermis and cuticle.

Stratigraphic Occurrence—Kansas specimens from the Fleming coal, Cabaniss Formation, Cherokee Group of the Desmoinesian series, Middle Pennsylvanian. Iowa specimens identifiable only as Desmoinesian series although they are believed (Baxter, 1962) to be of approximately the same age as the Kansas material.

Localities—Pittsburg and Midway Coal Company strip pits, approximately 3 miles northwest of Hallowell, Kansas, and the Patik Coal Mine, southwest of Oklaloosa, Iowa.

Type Material—Coal balls and peels in the University of Kansas Palaeobotanical Collection with the following numbers: M14, M29, M1048, M1082, M1242, M1263, M1267, Ia. 728.

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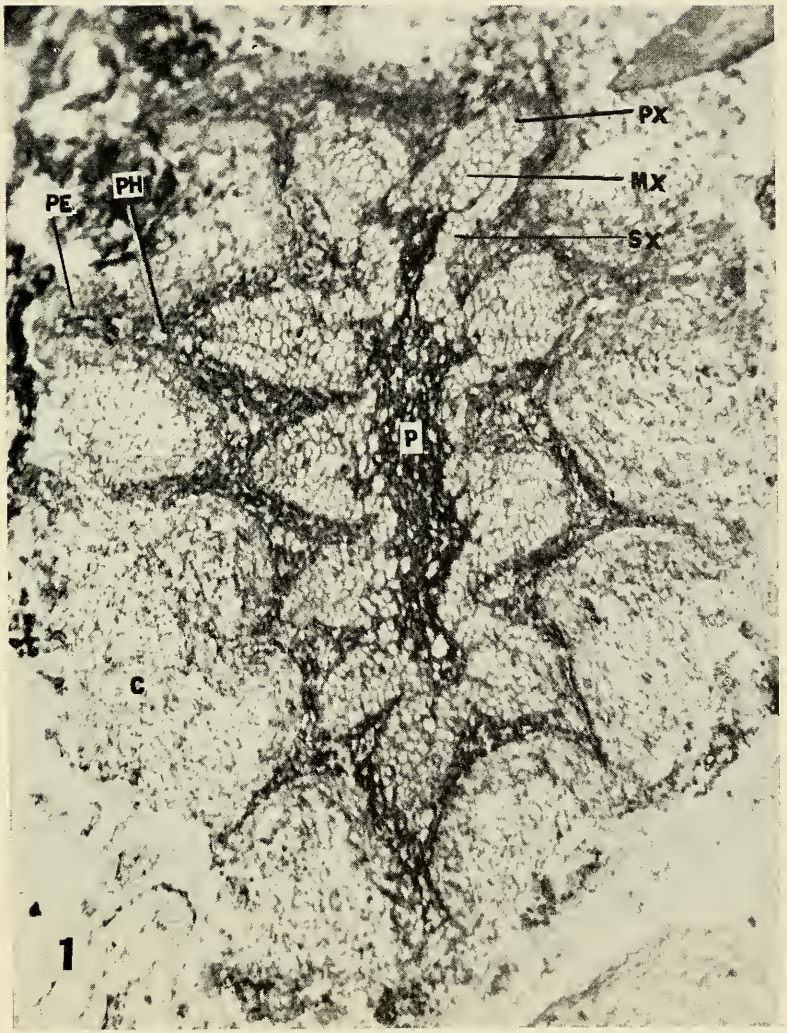

FIG. 1. *Stelastellara parvula.* Transverse section of specimen A. Note how periderm lobes extend through outer cortex. P, pith; Px, protoxylem; Mx, metaxylem; Sx, secondary xylem; Ph, phloem; Pe, periderm. See text fig. 1 and fig. 6 for enlarged detail. C. B. 1263d, P4.

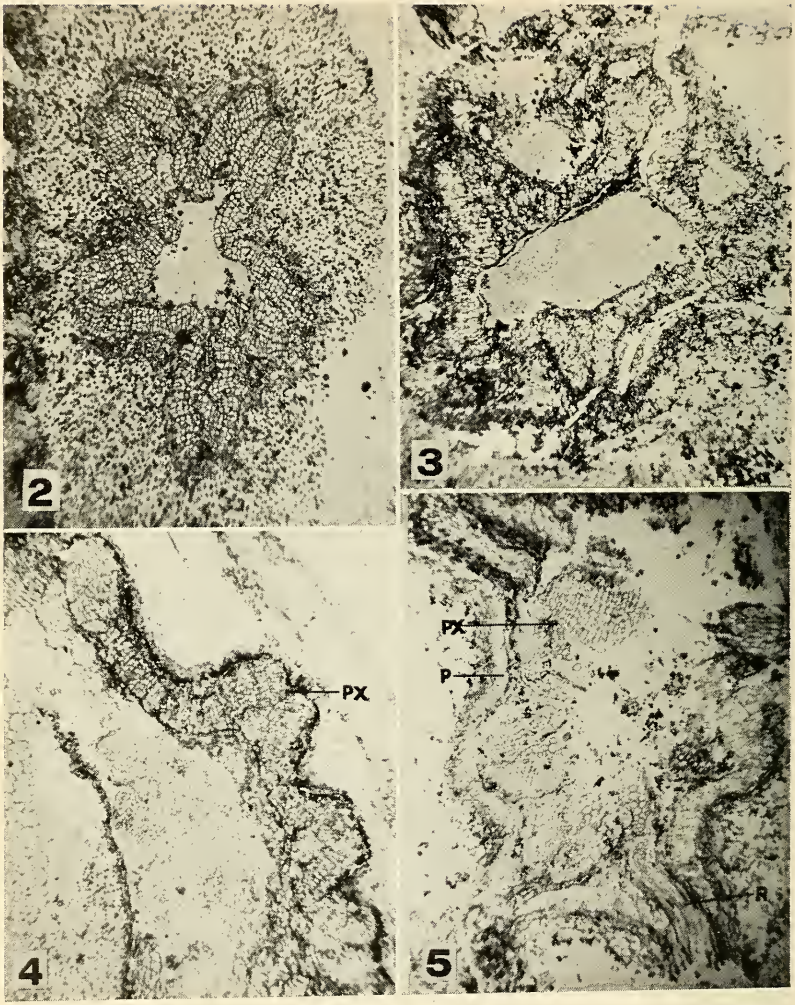

FIG. 2-5. *Stelastellara parvula*. Fig. 2—Transverse section of specimen B1 with pentarch stele, secondary xylem and showing typical "dotted" cortex. See fig. 7 for detail for one xylem arm. C. B. 1267B, p2. × 27. Fig. 3—Transverse section of specimen C from C. B. 1242F1P1 with 5 primary xylem strands, secondary xylem and a large pith area. Cortex lacking. × 20. Fig. 4—Transverse section of portion of stele of specimen D1. Px, protoxylem of one of our visible primary strands. Secondary xylem well developed. Dark line outside of secondary xylem represents phloem with a periderm surrounding it. C. B. 14A. × 21. Fig. 5—Transverse section of specimen E1 from Iowa Coal Ball. Px, protoxylem of an exarch primary strand. Four of the other five primary strands are also visible along left and bottom of section. R, an adventitious root (?) passing out from protoxylem of a primary stelar strand. P, periderm. Ia. C. B. 728B, pl. × 18.

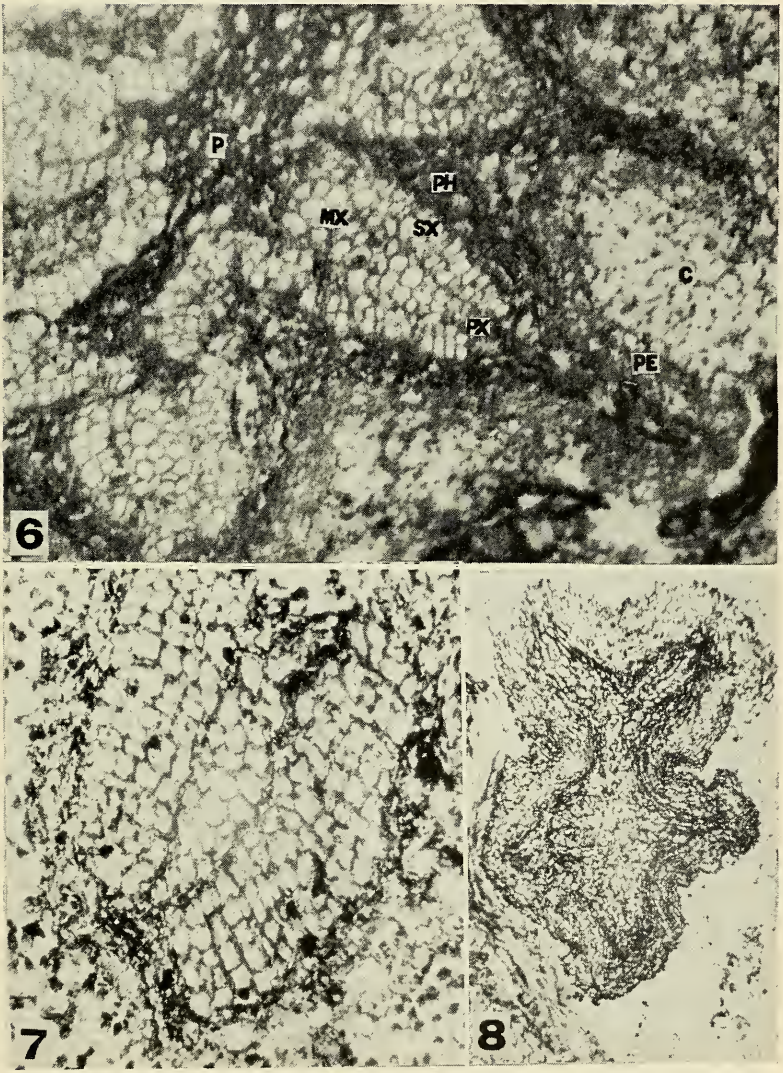

FIG. 6-8. *Stelastellara parvula.* Fig. 6—Enlarged section of portion of axis of specimen A shown in fig. 1. P, pith; Mx, metaxylem; Px, protoxylem; Sx, secondary xylem; Ph, phloem; Pe, periderm; C, cortex. The periderm lobe marked extends completely through the cortex. C. B. 1263, p4. × 80. Fig. 7—Enlarged portion of stele of specimen B1 shown in fig. 2. Primary xylem strand is in center with protoxylem point at lower left. Fascicular secondary xylem flanks metaxylem but does not cover protoxylem. "Dotted" cortex visible at left and below. C. B. 1267B, p2. × 90. Fig. 8—Transverse section of specimen F1 with pentarch primary xylem. Secondary xylem and periderm present. C. B. 1028A. × 25.

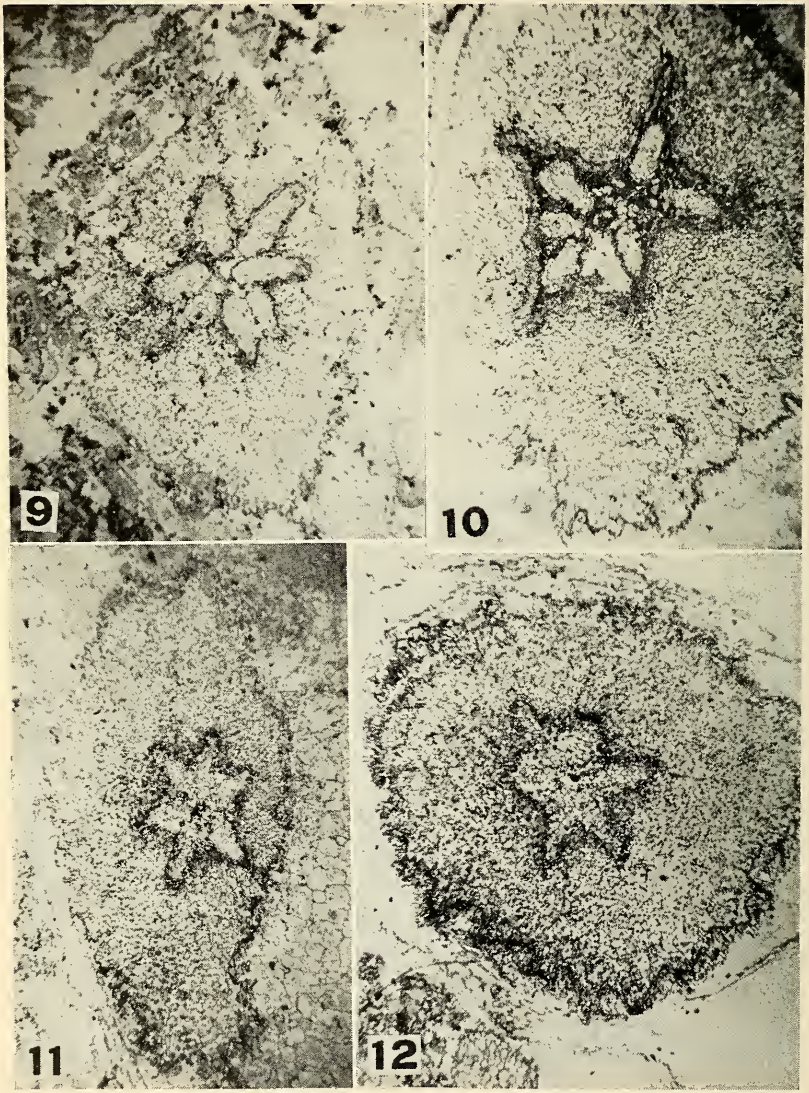

FIG. 9-12. *Stelastellara parvula.* Fig. 9—Transverse section of axis of specimen E2 showing seven primary bundles. Ia. C. B. 728A. × 27. Fig. 10—Transverse section of specimen D2 with six primary bundles and a well developed periderm. C. B. 14A. × 20. Fig. 11—Oblique-transverse section of specimen B2 showing six pointed star shaped stele. C. B. 1267B, p2. × 20. Fig. 12—Transverse section of same specimen (B2) shown in fig. 11 at a slightly different level. Note irregular, lobed surface of outer cortex. C. B. 1267B, p3. × 24.

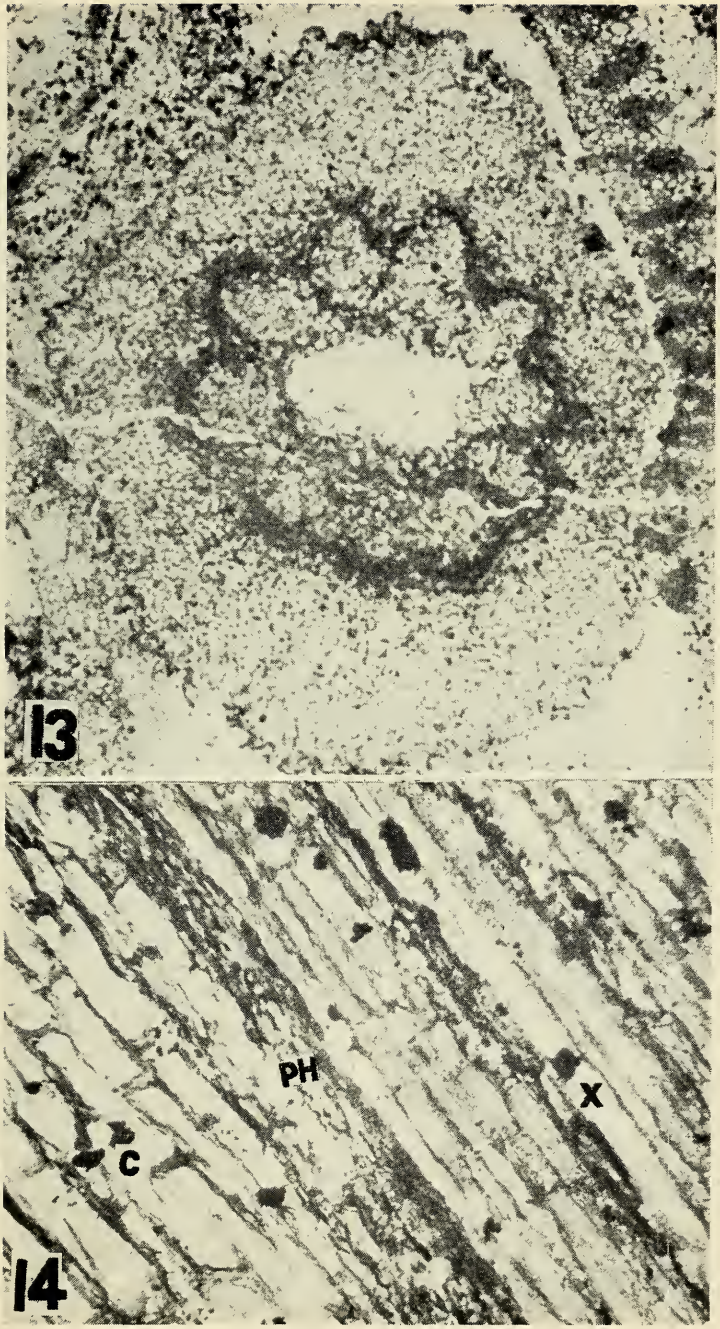

Fig. 13-14. *Stelastellara parvula.* Fig. 13—Transverse section of axis of specimen G. Note ten primary bundles and encircling periderm. C. B. 29B. × 16. Fig. 14—Radial-longitudinal section of specimen shown above. C, cortex; Ph, phloem and periderm; X, xylem. C. B. 29B. × 122.

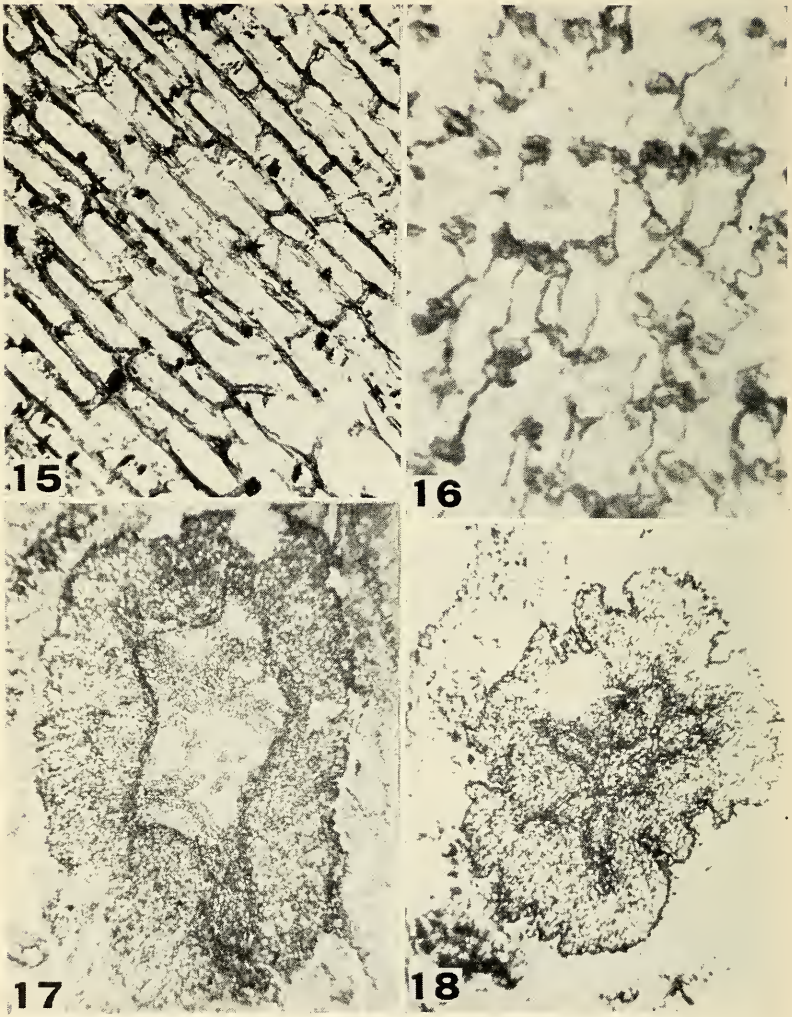

FIG. 15-18. *Stelastellara parvula.* Fig. 15—Longitudinal section of cortex. C. B. 1263, p4. × 115. Fig. 16—Transverse section of cortex. Note extreme thickenings on tangential walls and thin radial walls. C. B. 1263, p4. × 335. Fig. 17—Transverse section of axis of specimen F2. Center is poorly preserved but portions of a pentarch stele and secondary xylem are visible. C. B. 1082C. × 20. Fig. 18—Transverse section of axis of specimen H. Note furrows and lobes of outer cortex. C. B. 1048B. × 20.

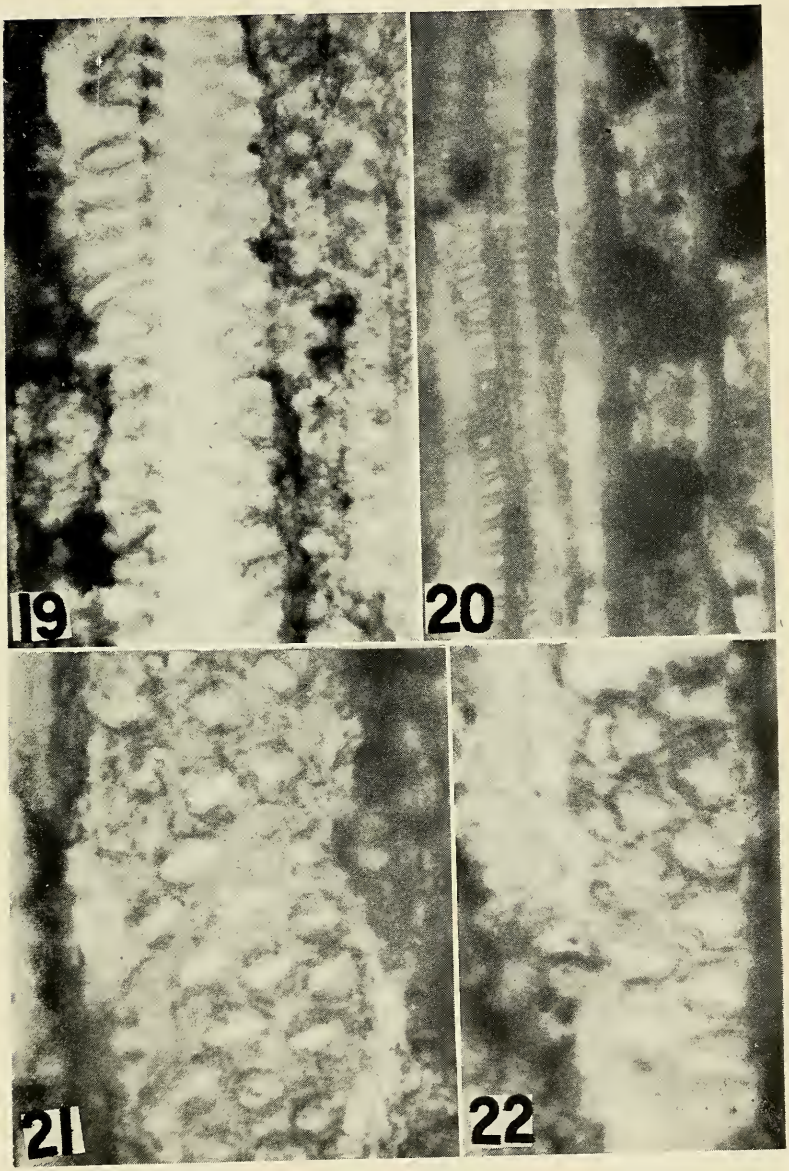

FIG. 19-22. *Stelastellara parvula.* Fig. 19—Longitudinal section of protoxylem showing annular thickenings of tracheid walls. C. B. 1267, p3. × 600. Fig. 20—Radial-longitudinal section of metaxylem showing transition from scalariform pitting on left to bordered pits on right. C. B. 29B, p10. × 360. Fig. 21—Lateral wall of metaxylem tracheid with alternate bordered pits. C. B. 1267B, p4. × 600. Fig. 22—Alternate bordered pits on radial wall of tracheid in secondary xylem. C. B. 1267B, p4. × 600.

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